# MPC5200B User's Manual

MPC5200BUM
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# Chapter 1
# Introduction

## 1.1 Overview

The digital communication networking and consumer markets require significant processor performance to enable operating systems and applications such as VxWorks™, QNX™, JAVA and soft modems. High integration is essential to reducing device and systems costs. The MPC5200B is specifically designed to meet these market needs while building on the family of microprocessors that use PowerPC™ architecture. For more information on PowerPC architecture, see "*The Programming Environments Manual for 32-bit Implementations of the PowerPC Architecture"*.

The MPC5200B integrates a high performance e300 core with a rich set of peripheral functions focused on communications and systems integration. The e300 core design is based on the PowerPC™ core architecture. The MPC5200B incorporates an innovative I/O subsystem, which isolates routine maintenance of peripheral functions from the embedded e300 core.

The MPC5200B supports a dual external bus architecture. It has a high speed SDRAM Bus interface that connects directly to the e300 core. In addition, the MPC5200B has a LocalPlus Bus used as a generalized interface to system level peripheral devices and debug environments.

### 1.1.1 Features

Key features are shown below.

- e300 core
  - Superscalar architecture
  - 760 MIPS at 400 MHz (-40 to +85°C)
  - 16k Instruction cache, 16k Data cache
  - Double precision FPU
  - Instruction and Data MMU
  - Standard & Critical interrupt capability
- SDRAM / DDR Memory Interface
  - up to 132MHz operation
  - SDRAM and DDR SDRAM support
  - 256-MByte addressing range per Chip Select (Two CS lines available)
  - 32-bit data bus
  - Built-in initialization and refresh

- Flexible multi-function External Bus Interface
  - — Supports interfacing to ROM/Flash/SRAM memories or other memory mapped devices
  - — 8 programmable Chip Selects
  - — Non multiplexed data access using 8/16/32 bit data bus with up to 26 bit address
  - — Short or Long Burst capable
  - — Multiplexed data access using 8/16/32 bit data bus with up to 25 bit address
- Peripheral Component Interconnect (PCI) Controller
  - — Version 2.2 PCI compatibility
  - — PCI initiator and target operation
  - — 32-bit PCI Address/Data bus
  - — 33 and 66 MHz operation
  - — PCI arbitration function
- ATA Controller
  - — Version 4 ATA compatible external interface—IDE Disk Drive connectivity
- BestComm DMA subsystem
  - — Intelligent virtual DMA Controller
  - — Dedicated DMA channels to control peripheral reception and transmission
  - — Local memory (SRAM 16kBytes)
- 6 Programmable Serial Controllers (PSC), configurable for:
  - — UART or RS232 interface
  - — CODEC interface for Soft Modem, Master/Slave CODEC Mode, $I^2S$ and AC97
  - — Full duplex SPI mode
  - — IrDA mode from 2400 bps to 4 Mbps
- Fast Ethernet Controller (FEC)
  - — Supports 100Mbps IEEE 802.3 MII, 10Mbps IEEE 802.3 MII, 10Mbps 7-wire interface
- Universal Serial Bus Controller (USB)
  - — USB Revision 1.1 Host
  - — Open Host Controller Interface (OHCI)
  - — Integrated USB Hub, with two ports.
- Two Inter-Integrated Circuit Interfaces ($I^2C$)
- Serial Peripheral Interface (SPI)
- Dual CAN 2.0 A/B Controller (MSCAN)
  - — Motorola Scalable CAN (MSCAN) architecture
  - — Implementation of version 2.0A/B CAN protocol
  - — Standard and extended data frames
- J1850 Byte Data Link Controller (BDLC)
  - — J1850 Class B data communication network interface compatible and ISO compatible for low speed (<125kbps) serial data communications in automotive applications.
  - — Supports 4X mode, 41.6 kbps
  - — In-frame response (IFR) types 0, 1, 2, and 3 supported

- Systems level features
  - Interrupt Controller supports 4 external interrupt request lines and 47 internal interrupt sources
  - GPIO/Timer functions
    - Up to 56 total GPIO pins (depending on functional multiplexing selections) that support a variety of interrupt/Wake Up capabilities.
    - 8 GPIO pins with timer capability supporting input capture, output compare and pulse width modulation (PWM) functions
  - Real-time Clock with 1 second resolution
  - Systems Protection (watch dog timer, bus monitor)
  - Individual control of functional block clock sources
  - Power management: Nap, Doze, Sleep, Deep Sleep modes
  - Support of Wake Up from low power modes by different sources (GPIO, RTC, CAN)
- Test/Debug features
  - JTAG (IEEE 1149.1 test access port)
  - Common On-Chip Processor (COP) debug port
- On-board PLL and clock generation
- Software
  - QNX
  - VXWorks
  - Linux
  - Software Modem capable
  - JAVA

## 1.2 Architecture

The following areas comprise the MPC5200B system architecture:

- Embedded e300 Core
- BestComm I/O Subsystem
- Controller Area Network (CAN)
- Byte Data Link Controller - Digital BDLC-D
- System Level Interfaces
- SDRAM Controller and Interface
- Multi-Function External LocalPlus Bus
- Power Management
- Systems Debug and Test
- Physical Characteristics

A dynamically managed external pin multiplexing scheme minimizes overall pin count. The result is low cost packaging and board assembly costs.

Figure 1-1 shows a simplified MPC5200B block diagram.

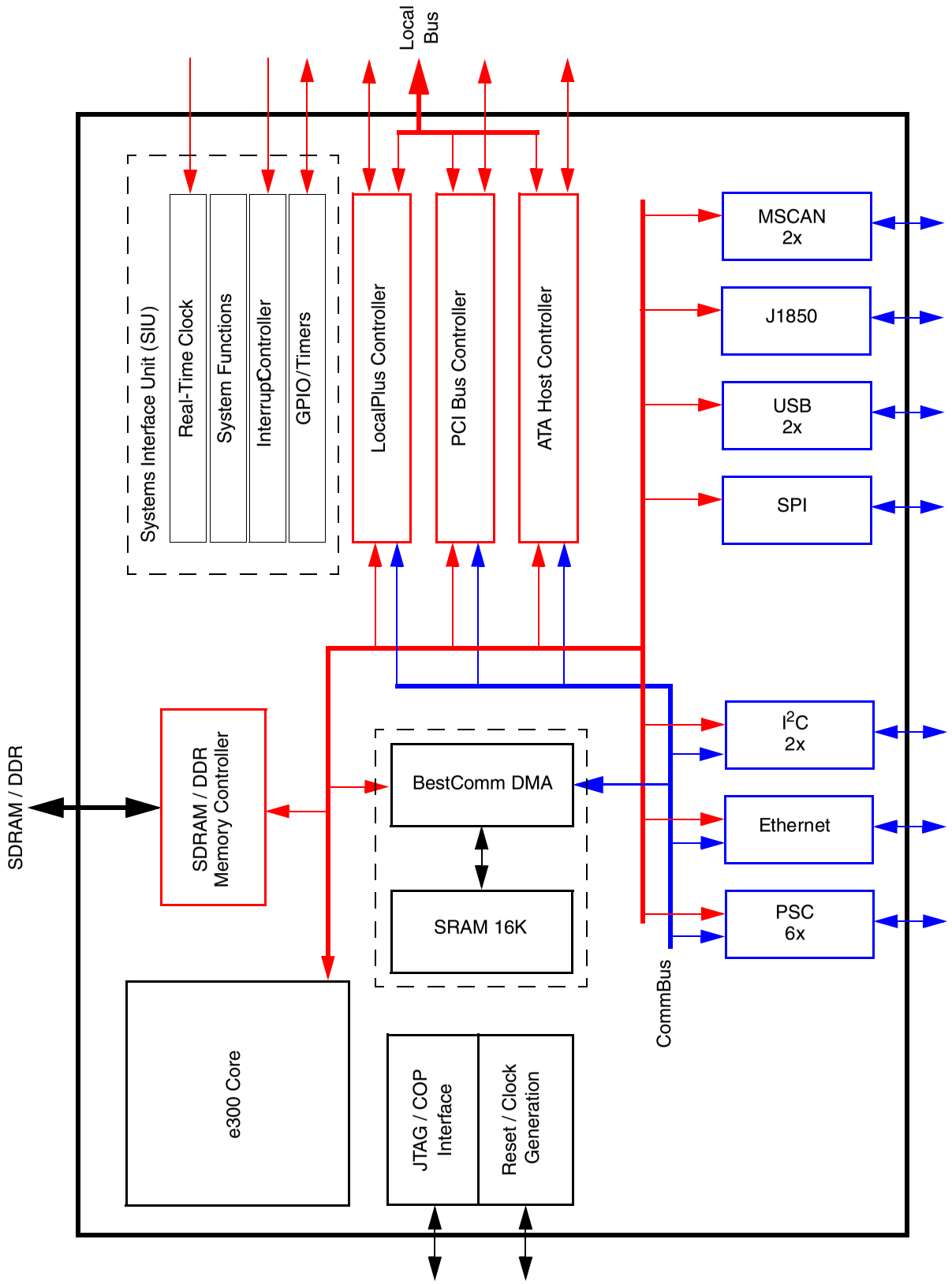



**Figure 1-1. Simplified Block Diagram—MPC5200B**

The MPC5200B supports a dual external bus architecture consisting of:

1. An SDRAM Bus
2. A multi-function LocalPlus Bus

The SDRAM Bus has a Memory Controller interface which supports standard SDRAM and Double Data Rate (DDR) SDRAM devices. The Memory Controller has 13 Memory Address (MA) lines multiplexed with 32 Data Bus lines. Standard SDRAM control signals are included.

The high-speed Memory Controller SDRAM interface connects directly to the microprocessor, allowing optimized instruction and data bursting. The dedicated memory interface, coupled with on-chip 16 Kilobyte instruction and 16Kilobyte data caches, enables high performance for computer intensive applications, such as Java and soft modems. Still, plenty of processing power remains for peripheral management and system control tasks.

The LocalPlus Bus provides for connection of external peripheral devices, disk storage, and slower speed memory. The LocalPlus Bus also supports an external Boot ROM/FLASH/SRAM interface.

The MPC5200B integrates a high performance e300 core with an I/O subsystem containing an intelligent Direct Memory Access (DMA) unit, BestComm. The BestComm unit is capable of:

- Responding to peripheral interrupts, independent of the e300 core.
- Providing low level peripheral management, protocol processing, and peripheral data movement functions.

The MPC5200B has an optimized peripheral mix to support today's embedded automotive and telematics requirements.

Figure 1-2 shows an MPC5200B-based system.

### 1.2.1 Embedded e300 Core

The MPC5200B embedded e300 core is derived from Freescale's (formerly Motorola) MPC603e family of Reduced Instruction Set Computer (RISC) microprocessors. The e300 core is a high-performance, low-power implementation of the PowerPC superscalar architecture. The MPC5200B e300 core contains:

- 16 KBytes of instruction cache
- 16 KBytes of data cache

Caches are 4-way set associative and use the Least Recently Used (LRU) replacement algorithm.

Four independent execution units are used:

1. Branch Processing Unit (BPU)
2. Integer Unit (IU)
3. Load/Store Unit (LSU)
4. System Register Unit (SRU)

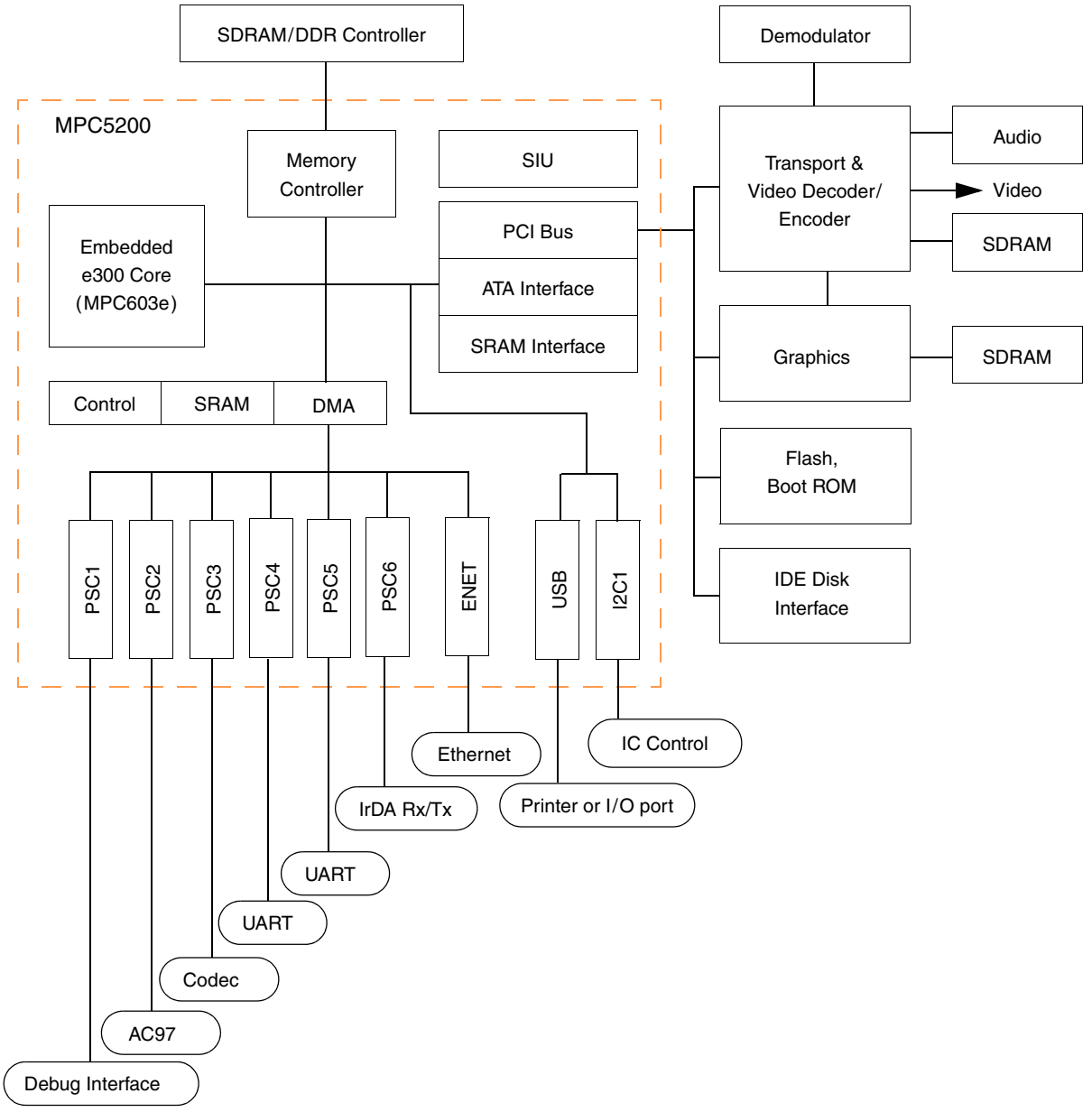



**Figure 1-2. MPC5200B-Based System**

Up to 3 instructions can be issued and retired per clock. Most instructions execute in a single cycle. The core contains an integrated Floating Point Unit (FPU), a Data Cache Memory Management Unit and an Instruction Cache Memory Management Unit. The core implements the 32-bit portion of the PowerPC architecture, which provides 32-bit effective addressing and integer data types of 8-, 16-, and 32-bits.

Enhancements in this core version, specific to embedded automotive/telematics include:

- Improved interrupt latency (critical interrupt)
- New MMU with additional 8 BAT (16 total) registers and 1KByte page management

The e300 core performance for SPEC95 benchmark integer operations, ranges between 4.4 and 5.1 at 200MHz. In Drystone 2.1MIPS, the e300 core is 280 MIPS at 200 MHz.

### 1.2.2 BestComm I/O Subsystem

BestComm contains an intelligent DMA unit. This unit provides a front-line interrupt control and data movement interface via a separate peripheral bus to the on-chip peripheral functions. This leaves the e300 core free for higher level activities. The concurrent operation enables a significant boost in overall systems performance.

BestComm supports up to 16 simultaneously enabled DMA tasks from up to 32 DMA requestors. Also included is:

- A hardware logic unit
- A hardware CRC unit

BestComm uses internal buffers for prefetched reads and post writes. Bursting is used whenever possible. This optimizes both internal and external bus activity.

#### 1.2.2.1 Programmable Serial Controllers (PSCs)

The MPC5200B supports six PSCs. Each can be configured to operate in different modes. PSCs support both synchronous and asynchronous protocols. They are used to interface to external full-function modems or external CODECs for soft modem support. 8, 16, 24 and 32-bit data widths are supported. PSCs can be configured to support 1200 baud POTS modem, SPI, $I^2S$, V.34 or V.90 protocols. The standard UART interface supports connection to an external terminal/computer for debug support.

#### 1.2.2.2 10/100 Ethernet Controller

The Ethernet Controller supports the following standard MAC-PHY interfaces:

- 100 Mbps IEEE 802.3 MII
- 10 Mbps IEEE 802.3 MII
- 10 Mbps 7-wire interface

The controller is full duplex, supports a programmable maximum frame length and retransmission from the Tx FIFO following a collision.

#### 1.2.2.3 Universal Serial Bus (USB)

The MPC5200B supports two USB channels. The USB Controller implements the USB Host Controller/Root Hub in compliance with the USB1.1 specification. The user may choose to have either one or two USB ports on the root hub, each of which can interface to an off-chip USB transceiver. The Host Controller supports the Open Host Controller Interface (OHCI) standard.

#### 1.2.2.4 Infrared Support

The MPC5200B supports the IrDA format. All three IrDA modes are supported (SIR, MIR, FIR) to 4.0 Mbps. The required 48 MHz clock can be generated internally or supplied externally on an input pin.

#### 1.2.2.5 Inter-Integrated Circuit ($I^2C$)

The MPC5200B supports two $I^2C$ channels. Both master and slave interfaces can be controlled directly by the processor or can use the BestComm Controller to buffer Tx/Rx data when the $I^2C$ data rate is high.

#### 1.2.2.6 Serial Peripheral Interface (SPI)

The SPI module allows full-duplex, synchronous, serial communication between the MPC5200B and peripheral devices. It supports master and slave mode, double-buffered operation and can operate in a polling or interrupt driven environment.

### 1.2.3 Controller Area Network (CAN)

The MPC5200B supports two CAN channels. The CAN is an asynchronous communications protocol used in automotive and industrial control systems. It is a high speed, short distance, priority based protocol that runs on a variety of mediums. For example, transmission media of fiber optic cable or unshielded twisted wire pairs can be used.

MSCAN supports both standard and extended identifier (ID) message formats specified in BOSCH CAN protocol specification, revision 2.0, part B. Each MSCAN module contains:

- 4 receive buffers (with FIFO storage scheme)
- 3 transmit buffers
- Flexible maskable identifier filters

### 1.2.4 Byte Data Link Controller - Digital BDLC-D

The MPC5200B supports J1850 Class B data communication network interface compatible and ISO compatible for low speed (<125 kbps) serial data communications in automotive applications.

- Hardware cyclical redundancy check (CRC) generation and checking
- Two power saving modes with automatic wake up on network activity
- Polling and CPU interrupt available
- Block mode receive/transmit supported
- Supports 4X mode, 41.6 kbps
- In-frame response (IFR) types 0, 1, 2, and 3 supported
- Wake up on J1850 message

### 1.2.5 System Level Interfaces

System Level Interfaces are listed below and described in the sections that follow:

- Chip Selects
- Interrupt Controller
- Timers
- General Purpose Input/Outputs (GPIO)
- Functional Pin Multiplexing
- Real-Time Clock (RTC)

#### 1.2.5.1 Chip Selects

The MPC5200B integrates the most common system integration interfaces and signals. There are 8 fully programmable external chip selects, which are independent of the SDRAM interface. LP_CS0 has special features to support a Boot ROM. Two of the chip selects may be used by the IDE disk drive interface, when enabled.

#### 1.2.5.2 Interrupt Controller

The Interrupt Controller has 4 external interrupt signals and manages both external and internal interrupts. All interrupt levels and priorities are programmable.

The Interrupt Controller takes advantage of the new critical interrupt feature defined by the PowerPC architecture. This allows e300 core interrupts outside operating system boundaries, for critical functions such as real-time packet processing.

#### 1.2.5.3 Timers

MPC5200B integrates several timer functions required by most embedded systems:

- Two internal Slice timers can create short-cycle periodic interrupts.
- A WatchDog timer can interrupt the processor if not regularly serviced, catching software hang-ups.

A bus monitor monitors bus cycles and provides an interrupt if transactions take longer than a prescribed time.

#### 1.2.5.4 General Purpose Input/Outputs (GPIO)

A total of 56 pins on the MPC5200B can be programmed as GPIOs.

- 8 pins can interrupt the processor.
- 8 pins can support a “Wake Up” capability that brings the MPC5200B out of low power modes.
- 8 pins are “output only” GPIOs.

The remaining GPIO pins support a simple “set the output level” or “detect the input level” type GPIO function. Eight I/Os can be connected to one of eight general purpose timers to support input capture, output compare or pulse width modulation functions.

The number of GPIOs available in the various modes depends on the peripheral functionality required. See pin descriptions and I/O port maps below for more information.

#### 1.2.5.5 Functional Pin Multiplexing

Many serial/parallel port pins serve multiple functions, allowing flexibility in optimizing the system to meet a specific set of integration requirements. For example, when PSC3 interfaces to a full function external modem, 10 pins are required:

- PSC3_TXD—Transmit Data
- PSC3_RXD—Receive Data
- PSC3_$\overline{\text{RTS}}$—Ready to Send
- PSC3_$\overline{\text{CTS}}$—Clear to Send
- PSC3_CD—Carrier Detect
- MODEM_RI—Ring Indicator
- MODEM_DSR—Hook Switch
- MODEM_IO—Control I/O (A0 gain)
- MODEM_IO—Control I/O (Mode 1)
- MODEM_IO—Control I/O (Mode 2)

If PSC3 connects to a simple UART, only the first four signals (shown above) are required. The remaining 6 signals can be used as GPIOs.

If a 7-wire Ethernet connection is adequate, the additional 11 Ethernet I/Os can be used as GPIOs.

#### 1.2.5.6 Real-Time Clock (RTC)

An RTC is included on the MPC5200B. The RTC provides a 2-pin interface to an external 32.768 kHz crystal. This allows internal time-of-day/calendar tracking, as well as clock based periodic interrupts.

### 1.2.6 SDRAM Controller and Interface

The MPC5200B high speed SDRAM Controller supports both standard SDRAM and Double Data Rate (DDR) SDRAM devices. It supports up to 256 MBytes per chip select (2 Chip Select lines available) with a 32-bit interface. Memory sizes of 64 Mbit, 128 Mbit, 256 Mbit and 512 Mbit are supported.

### 1.2.7 Multi-Function External LocalPlus Bus

The MPC5200B supports a multi-function external LocalPlus Bus to allow connections to PCI and ATA compliant devices, as well as external ROM/SRAM.

The MPC5200B integrates a 3.3 V, PCI V2.2 compatible external LocalPlus Bus controller and interface. This bus is a 32-bit multiplexed address/data bus.

The external LocalPlus Bus provides support for an ATA disk drive interface. ATA control signals (chip selects, write/read, etc.) are provided independent of the PCI control signals. This prevents bus contention. However, the 32-bit data bus is shared. When The MPC5200B recognizes an external LocalPlus Bus access meant for the ATA Controller, ATA control logic arbitrates for PCI interface control. The 32-bit address/data bus function is transformed into 16bits of ATA data and 3bits of ATA address.

The external LocalPlus Bus also allows connection to external memory or peripheral devices that adhere to a ROM or SRAM-like interface. These devices occupy a separate location in the memory map and have independent control signals. When an internal access is decoded to fall in the SRAM/ROM memory space, the 32-bit PCI address/data bus is transformed into either:

- 24bits of address and 8bits of data
- 16bits of address and 16bits of data.

The MPC5200B supports a reset configuration mode common on the family of processors that use the PowerPC architecture. 16 bits of configuration information is driven and sampled during reset to establish the initial processor configuration.

### 1.2.8 Power Management

The MPC5200B is processed in a low-power static CMOS technology. In addition, it supports the dynamic power management modes available on the MPC52xx series processors using the e300 core. These modes include:

- Nap
- Dose
- Sleep
- Deep sleep

In deep sleep, all internal clocks can be disabled, thus, reducing the power draw to CMOS leakage levels.

A Wake Up capability is supported by CAN, RTC, several GPIOs and the interrupt lines. Therefore, the MPC5200B can be shut down to a low-power standby mode, then re-enabled by one of the Wake Up inputs without resetting the MPC5200B.

### 1.2.9 Systems Debug and Test

The MPC5200B supports the Common On-chip Processor (COP) debug capability common on other microprocessors that use the PowerPC architecture. The COP interface supports features such as:

- Memory down load
- Single step instruction execution
- Break/watch point capability
- Access to internal registers
- Pipeline tracking, etc.

The MPC5200B also supports a JTAG IEEE 1149.1 controller and test access port (TAP).

### 1.2.10 Physical Characteristics

- 1.5 V internal, 3.3 V external operation (2.5 V for DDR interface)
- TTL compatible I/O pins
- 272-pin Plastic Ball Grid Array (PBGA)

# Chapter 2
# Signal Descriptions

## 2.1 Overview

The MPC5200B contains a e300 core, an internal DMA engine, BestComm, multiple functional blocks and associated I/O ports. There are two external data/address bus structures, the LocalPlus bus and SDRAM bus. A block diagram of the MPC5200B structure is shown in Figure 1-1.

In general, the LocalPlus bus connects to external SRAM, FLASH, peripheral devices, etc. The LocalPlus bus is capable of executing standard memory cycles, PCI cycles and ATA cycles. In addition to the data and address bus pins on the LocalPlus bus, there are pins specifically dedicated to ATA transactions, PCI transactions and standard memory transactions. When the MPC5200B is released from reset, Chip Select 0 is the only active chip select. Program execution must always start from the “boot device” on the LocalPlus bus. There are 8 chip select signals associated with the LocalPlus bus. It’s possible to execute from every CS. Also every CS can address “data space”.

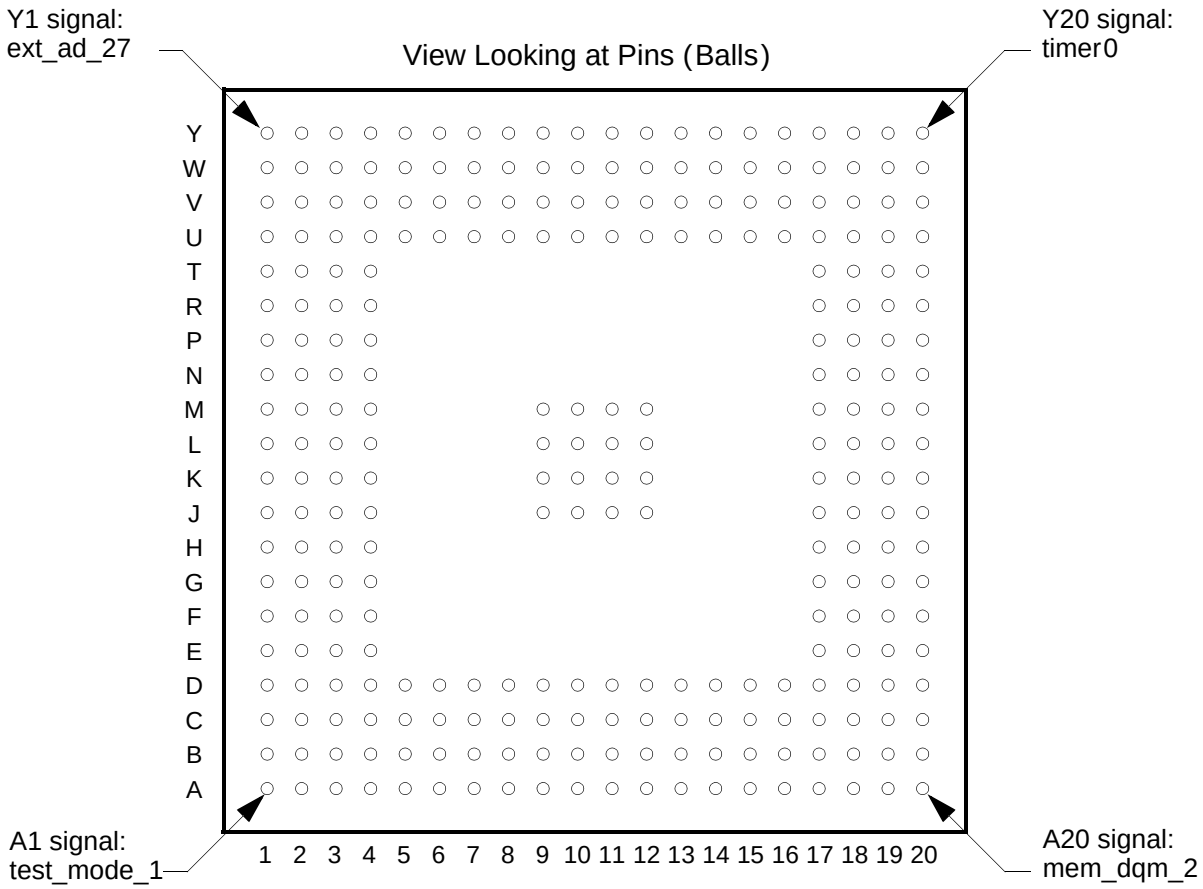
The SDRAM bus interfaces to Synchronous DRAM. Both Single Data Rate and Double Data Rate DRAMs are supported. Executable programs are generally loaded into memory residing on the SDRAM bus. The SDRAM bus has a 32-bit wide data/address bus structure and is capable of burst accesses. It is possible to execute program code over the LocalPlus bus. However, the data transfer rate on the SDRAM bus is many times faster than LocalPlus.

There are 16 peripheral functional blocks on the MPC5200B. These are General Purpose I/O, I2C, TIMER, PSC1, PSC2, PSC3, PSC4, PSC5, PSC6, Ethernet, USB, MSCAN, SPI and J1850. Each of these functional blocks are routed to one or more I/O ports through a system of multiplexers. A functional block can only be routed to one I/O port at a time and in many cases, several functional blocks can be routed to the same I/O port.

The I/O ports are Dedicated GPIO Group, $I^2C$ Group, Timer Group, PSC1 Group, PSC2 Group, PSC3 Group, PSC6 Group, Ethernet Group, and the USB Group.

Figure 2-3 through Figure 2-12 present detailed on the multiplexing options for each I/O port.

MPC5200B is packaged in a 272-pin Plastic Ball Gate Array (PBGA). Package ball locations are shown in Figure 2-1. See Figure 2-2 for case diagram.




**Notes:** Table 2-1 and Table 2-2 give the signals on each pin/ball.

**Figure 2-1. 272-Pin PBGA Pin Detail**

Table 2-1 gives a list of MPC5200B I/O signals sorted by package ball name. Table 2-2 gives the same list sorted by signal name.

Many signal pins can have multiple functions depending on internal register settings. These additional functions are described in Table 2-3 through Table 2-31.

| A01 TEST_MODE_1 | A02 JTAG_TDO | A03 JTAG_TDI | A04 JTAG_TMS | A05 PSC3_8 | A06 PSC3_5 | A07 PSC3_2 | A08 PSC2_4 | A09 PSC2_2 | A10 PSC1_4 | A11 PSC1_1 | A12 PSC6_2 | A13 PORRESET | A14 SRESET | A15 SYS_XTAL_IN | A16 MEM_MA_1 | A17 MEM_MBA_1 | A18 MEM_RAS | A19 MEM_WE | A20 MEM_DQM_2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B01 TEST_SEL_0 | B02 TEST_MODE_0 | B03 JTAG_TRST | B04 JTAG_TCK | B05 PSC3_7 | B06 PSC3_4 | B07 PSC3_1 | B08 PSC2_3 | B09 PSC2_1 | B10 PSC1_3 | B11 PSC1_0 | B12 PSC6_0 | B13 HRESET | B14 SYS_PLL_AVDD | B15 SYS_PLL_TPA | B16 MEM_MA_2 | B17 MEM_MA_10 | B18 MEM_CS_0 | B19 MEM_CAS | B20 MEM_MA_4 |
| C01 RTC_XTAL_OUT | C02 RTC_XTAL_IN | C03 TEST_SEL_1 | C04 PSC3_9 | C05 PSC3_6 | C06 PSC3_3 | C07 PSC3_0 | C08 CORE_PLL_AVDD | C09 PSC2_0 | C10 PSC1_2 | C11 PSC6_1 | C12 GPIO_WKUP_7 | C13 PSC6_3 | C14 SYS_PLL_AVSS | C15 GPIO_WKUP_6 | C16 MEM_MA_3 | C17 MEM_MA_0 | C18 MEM_MBA_0 | C19 MEM_MA_5 | C20 MEM_MA_6 |
| D01 TIMER_4 | D02 TIMER_3 | D03 TIMER_2 | D04 VSS | D05 VDD_CORE | D06 VDD_IO | D07 VDD_CORE | D08 LP_OE | D09 VDD_IO | D10 VDD_CORE | D11 VDD_CORE | D12 VDD_MEM_IO | D13 VDD_MEM_IO | D14 SYS_XTAL_OUT | D15 VDD_MEM_IO | D16 VSS | D17 VDD_MEM_IO | D18 MEM_MDQS_2 | D19 MEM_MA_7 | D20 MEM_MA_8 |
| E01 TIMER_7 | E02 TIMER_6 | E03 TIMER_5 | E04 VDD_IO | | | | | | | | | | | | | E17 VDD_MEM_IO | E18 MEM_MDQ_16 | E19 MEM_MA_9 | E20 MEM_MA_11 |
| F01 USB_7 | F02 USB_8 | F03 USB_9 | F04 VDD_IO | | | | | | | | | | | | | F17 VDD_MEM_IO | F18 MEM_MDQ_17 | F19 MEM_MA_12 | F20 MEM_CLK_EN |
| G01 USB_3 | G02 USB_4 | G03 USB_5 | G04 USB_6 | | | | | | | | | | | | | G17 MEM_MDQ_18 | G18 MEM_MDQ_19 | G19 MEM_CLK | G20 MEM_CLK |
| H01 USB_0 | H02 USB_1 | H03 USB_2 | H04 VDD_IO | | | | | | | | | | | | | H17 d VDD_MEM_IO | H18 203 MEM_MDQ_20 | H19 204 MEM_DQM_1 | H20 206 MEM_MDQS_1 |
| J01 ETH_3 | J02 ETH_4 | J03 ETH_10 | J04 ETH_17 | | | | | J09 VSS | J10 VSS | J11 VSS | J12 VSS | | | | | J17 MEM_MDQ_22 | J18 MEM_MDQ_21 | J19 MEM_MDQ_8 | J20 MEM_MDQ_9 |
| K01 ETH_0 | K02 ETH_1 | K03 ETH_2 | K04 VDD_CORE | | | | | K09 VSS | K10 VSS | K11 VSS | K12 VSS | | | | | K17 d VDD_MEM_IO | K18 193 MEM_MDQ_23 | K19 194 MEM_MDQ_10 | K20 196 MEM_MDQ_11 |
| L01 ETH_9 | L02 ETH_16 | L03 ETH_5 | L04 ETH_11 | | | | | L09 VSS | L10 VSS | L11 VSS | L12 VSS | | | | | L17 MEM_DQM_3 | L18 MEM_MDQS_3 | L19 MEM_MDQ_12 | L20 MEM_MDQ_13 |
| M01 ETH_13 | M02 ETH_12 | M03 ETH_8 | M04 VDD_CORE | | | | | M09 VSS | M10 VSS | M11 VSS | M12 VSS | | | | pl | M17 d VDD_MEM_IO | M18 182 MEM_MDQ_24 | M19 184 MEM_MDQ_14 | M20 186 MEM_MDQ_15 |
| N01 ETH_7 | N02 ETH_6 | N03 ETH_15 | N04 ETH_14 | | | | | | | | | | | | | N17 MEM_MDQ_25 | N18 MEM_MDQ_26 | N19 MEM_DQM_0 | N20 MEM_MDQS_0 |
| P01 IRQ1 | P02 IRQ2 | P03 IRQ0 | P04 VDD_CORE | | | | | | | | | | | | | P17 d VDD_MEM_IO | P18 172 MEM_MDQ_27 | P19 174 MEM_MDQ_7 | P20 176 MEM_MDQ_6 |
| R01 IRQ3 | R02 PCI_RESET | R03 EXT_AD_30 | R04 PCI_GNT | | | | | | | | | | | | | R17 MEM_MDQ_28 | R18 MEM_MDQ_29 | R19 MEM_MDQ_5 | R20 MEM_MDQ_4 |
| T01 PCI_CLOCK | T02 EXT_AD_26 | T03 EXT_AD_28 | T04 VDD_IO | | | | | | | | | | | | | T17 VDD_MEM_IO | T18 MEM_MDQ_30 | T19 MEM_MDQ_3 | T20 MEM_MDQ_2 |
| U01 PCI_REQ | U02 PCI_IDSEL | U03 EXT_AD_24 | U04 VSS | U05 VDD_IO | U06 VDD_IO | U07 VDD_CORE | U08 EXT_AD_15 | U09 VDD_IO | U10 VDD_IO | U11 EXT_AD_6 | U12 VDD_CORE | U13 VDD_IO | U14 LP_ACK | U15 VDD_CORE | U16 VDD_IO | U17 VSS | U18 MEM_MDQ_31 | U19 MEM_MDQ_1 | U20 MEM_MDQ_0 |
| V01 EXT_AD_31 | V02 EXT_AD_20 | V03 EXT_AD_22 | V04 EXT_AD_18 | V05 PCI_FRAME | V06 PCI_STOP | V07 PCI_PAR | V08 EXT_AD_13 | V09 EXT_AD_11 | V10 EXT_AD_9 | V11 EXT_AD_4 | V12 EXT_AD_2 | V13 EXT_AD_0 | V14 LP_ALE | V15 LP_CS2 | V16 LP_CS5 | V17 ATA_DRQ | V18 TIMER_1 | V19 I2C_0 | V20 I2C_2 |
| W01 EXT_AD_29 | W02 EXT_AD_25 | W03 EXT_AD_23 | W04 EXT_AD_16 | W05 PCI_TRDY | W06 PCI_CBE_2 | W07 PCI_DEVSEL | W08 PCI_SERR | W09 EXT_AD_14 | W10 PCI_CBE_0 | W11 EXT_AD_8 | W12 EXT_AD_5 | W13 EXT_AD_1 | W14 LP_CS0 | W15 LP_CS3 | W16 LP_RW | W17 ATA_IOW | W18 ATA_IOCHRDY | W19 I2C_1 | W20 I2C_3 |
| Y01 EXT_AD_27 | Y02 PCI_CBE_3 | Y03 EXT_AD_21 | Y04 EXT_AD_19 | Y05 EXT_AD_17 | Y06 PCI_IRDY | Y07 PCI_PERR | Y08 PCI_CBE_1 | Y09 EXT_AD_12 | Y10 EXT_AD_10 | Y11 EXT_AD_7 | Y12 EXT_AD_3 | Y13 LP_TS | Y14 LP_CS1 | Y15 LP_CS4 | Y16 ATA_ISOLATION | Y17 ATA_IOR | Y18 ATA_DACK | Y19 ATA_INTRQ | Y20 TIMER_0 |

Key for IO Balls:

| A6 |
|---|
| PSC3_5 |

<– Ball

<– Signal Name

Key for PWR/GND Balls:

| | |
|---|---|
| VSS | Core and IO VSS |
| VDD_CORE | 1.5V Core VDD |
| VDD IO | 3.3V IO VDD |
| VDD_MEM_IO | Memory VDD |

**Figure 2-2. 272-Pin PBGA — Top View**

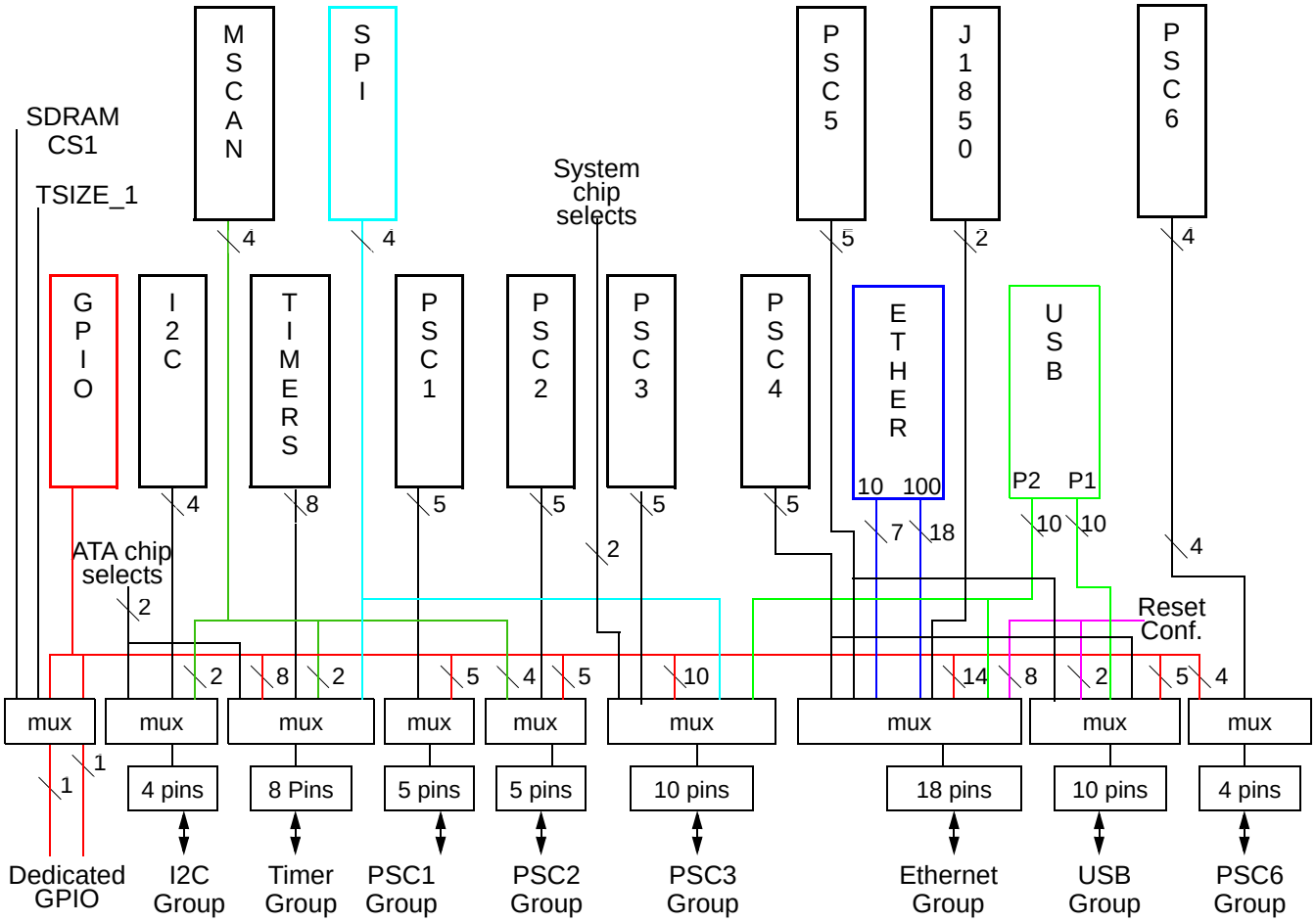



**Figure 2-3. MPC5200B Peripheral Muxing**

## 2.2 Pinout Tables

**Table 2-1. Signals by Ball/Pin (Sheet 1 of 4)**

| Ball/Pin | Pin Name |
|---|---|
| A01 | TEST_MODE_1 |
| A02 | JTAG_TDO |
| A03 | JTAG_TDI |
| A04 | JTAG_TMS |
| A05 | PSC3_8 |
| A06 | PSC3_5 |
| A07 | PSC3_2 |
| A08 | PSC2_4 |
| A09 | PSC2_2 |
| A10 | PSC1_4 |
| A11 | PSC1_1 |
| A12 | PSC6_2 |
| A13 | PORRESET |
| A14 | SRESET |
| A15 | SYS_XTAL_IN |
| A16 | MEM_MA_1 |
| A17 | MEM_MBA_1 |
| A18 | MEM_RAS |
| A19 | MEM_WE |
| A20 | MEM_DQM_2 |
| B01 | TEST_SEL_0 |
| B02 | TEST_MODE_0 |
| B03 | JTAG_TRST |
| B04 | JTAG_TCK |
| B05 | PSC3_7 |
| B06 | PSC3_4 |
| B07 | PSC3_1 |
| B08 | PSC2_3 |
| B09 | PSC2_1 |
| B10 | PSC1_3 |
| B11 | PSC1_0 |
| B12 | PSC6_0 |
| B13 | HRESET |
| B14 | SYS_PLL_AVDD |
| B15 | SYS_PLL_TPA |
| D11 | VDD_CORE |
| D12 | VDD_MEM_IO |
| D13 | VDD_MEM_IO |

| Ball/Pin | Pin Name |
|---|---|
| B16 | MEM_MA_2 |
| B17 | MEM_MA_10 |
| B18 | MEM_CS_0 |
| B19 | MEM_CAS |
| B20 | MEM_MA_4 |
| C01 | RTC_XTAL_OUT |
| C02 | RTC_XTAL_IN |
| C03 | TEST_SEL_1 |
| C04 | PSC3_9 |
| C05 | PSC3_6 |
| C06 | PSC3_3 |
| C07 | PSC3_0 |
| C08 | CORE_PLL_AVDD |
| C09 | PSC2_0 |
| C10 | PSC1_2 |
| C11 | PSC6_1 |
| C12 | GPIO_WKUP_7 |
| C13 | PSC6_3 |
| C14 | SYS_PLL_AVSS |
| C15 | GPIO_WKUP_6 |
| C16 | MEM_MA_3 |
| C17 | MEM_MA_0 |
| C18 | MEM_MBA_0 |
| C19 | MEM_MA_5 |
| C20 | MEM_MA_6 |
| D01 | TIMER_4 |
| D02 | TIMER_3 |
| D03 | TIMER_2 |
| D04 | VSS_IO/CORE |
| D05 | VDD_CORE |
| D06 | VDD_IO |
| D07 | VDD_CORE |
| D08 | LP_OE |
| D09 | VDD_IO |
| D10 | VDD_CORE |
| H04 | VDD_IO |
| H17 | VDD_MEM_IO |
| H18 | MEM_MDQ_20 |

**Table 2-1. Signals by Ball/Pin (Sheet 2 of 4)**

| Ball/Pin | Pin Name |
|---|---|
| D14 | SYS_XTAL_OUT |
| D15 | VDD_MEM_IO |
| D16 | VSS_IO/CORE |
| D17 | VDD_MEM_IO |
| D18 | MEM_MDQS_2 |
| D19 | MEM_MA_7 |
| D20 | MEM_MA_8 |
| E01 | TIMER_7 |
| E02 | TIMER_6 |
| E03 | TIMER_5 |
| E04 | VDD_IO |
| E17 | VDD_MEM_IO |
| E18 | MEM_MDQ_16 |
| E19 | MEM_MA_9 |
| E20 | MEM_MA_11 |
| F01 | USB_7 |
| F02 | USB_8 |
| F03 | USB_9 |
| F04 | VDD_IO |
| F17 | VDD_MEM_IO |
| F18 | MEM_MDQ_17 |
| F19 | MEM_MA_12 |
| F20 | MEM_CLK_EN |
| G01 | USB_3 |
| G02 | USB_4 |
| G03 | USB_5 |
| G04 | USB_6 |
| G17 | MEM_MDQ_18 |
| G18 | MEM_MDQ_19 |
| G19 | MEM_CLK |
| G20 | MEM_CLK |
| H01 | USB_0 |
| H02 | USB_1 |
| H03 | USB_2 |
| L17 | MEM_DQM_3 |
| L18 | MEM_MDQS_3 |
| L19 | MEM_MDQ_12 |
| L20 | MEM_MDQ_13 |
| M01 | ETH_13 |
| M02 | ETH_12 |

| Ball/Pin | Pin Name |
|---|---|
| H19 | MEM_DQM_1 |
| H20 | MEM_MDQS_1 |
| J01 | ETH_3 |
| J02 | ETH_4 |
| J03 | ETH_10 |
| J04 | ETH_17 |
| J09 | VSS_IO/CORE |
| J10 | VSS_IO/CORE |
| J11 | VSS_IO/CORE |
| J12 | VSS_IO/CORE |
| J17 | MEM_MDQ_22 |
| J18 | MEM_MDQ_21 |
| J19 | MEM_MDQ_8 |
| J20 | MEM_MDQ_9 |
| K01 | ETH_0 |
| K02 | ETH_1 |
| K03 | ETH_2 |
| K04 | VDD_CORE |
| K09 | VSS_IO/CORE |
| K10 | VSS_IO/CORE |
| K11 | VSS_IO/CORE |
| K12 | VSS_IO/CORE |
| K17 | VDD_MEM_IO |
| K18 | MEM_MDQ_23 |
| K19 | MEM_MDQ_10 |
| K20 | MEM_MDQ_11 |
| L01 | ETH_9 |
| L02 | ETH_16 |
| L03 | ETH_5 |
| L04 | ETH_11 |
| L09 | VSS_IO/CORE |
| L10 | VSS_IO/CORE |
| L11 | VSS_IO/CORE |
| L12 | VSS_IO/CORE |
| R18 | MEM_MDQ_29 |
| R19 | MEM_MDQ_5 |
| R20 | MEM_MDQ_4 |
| T01 | PCI_CLOCK |
| T02 | EXT_AD_26 |
| T03 | EXT_AD_28 |

**Table 2-1. Signals by Ball/Pin (Sheet 3 of 4)**

| Ball/Pin | Pin Name |
|---|---|
| M03 | ETH_8 |
| M04 | VDD_CORE |
| M09 | VSS_IO/CORE |
| M10 | VSS_IO/CORE |
| M11 | VSS_IO/CORE |
| M12 | VSS_IO/CORE |
| M17 | VDD_MEM_IO |
| M18 | MEM_MDQ_24 |
| M19 | MEM_MDQ_14 |
| M20 | MEM_MDQ_15 |
| N01 | ETH_7 |
| N02 | ETH_6 |
| N03 | ETH_15 |
| N04 | ETH_14 |
| N17 | MEM_MDQ_25 |
| N18 | MEM_MDQ_26 |
| N19 | MEM_DQM_0 |
| N20 | MEM_MDQS_0 |
| P01 | IRQ1 |
| P02 | IRQ2 |
| P03 | IRQ0 |
| P04 | VDD_CORE |
| P17 | VDD_MEM_IO |
| P18 | MEM_MDQ_27 |
| P19 | MEM_MDQ_7 |
| P20 | MEM_MDQ_6 |
| R01 | IRQ3 |
| R02 | PCI_RESET |
| R03 | EXT_AD_30 |
| R04 | PCI_GNT |
| R17 | MEM_MDQ_28 |
| V07 | PCI_PAR |
| V08 | EXT_AD_13 |
| V09 | EXT_AD_11 |
| V10 | EXT_AD_9 |
| V11 | EXT_AD_4 |
| V12 | EXT_AD_2 |
| V13 | EXT_AD_0 |
| V14 | LP_ALE |
| V15 | LP_CS2 |

| Ball/Pin | Pin Name |
|---|---|
| T04 | VDD_IO |
| T17 | VDD_MEM_IO |
| T18 | MEM_MDQ_30 |
| T19 | MEM_MDQ_3 |
| T20 | MEM_MDQ_2 |
| U01 | PCI_REQ |
| U02 | PCI_IDSEL |
| U03 | EXT_AD_24 |
| U04 | VSS_IO/CORE |
| U05 | VDD_IO |
| U06 | VDD_IO |
| U07 | VDD_CORE |
| U08 | EXT_AD_15 |
| U09 | VDD_IO |
| U10 | VDD_IO |
| U11 | EXT_AD_6 |
| U12 | VDD_CORE |
| U13 | VDD_IO |
| U14 | LP_ACK |
| U15 | VDD_CORE |
| U16 | VDD_IO |
| U17 | VSS_IO/CORE |
| U18 | MEM_MDQ_31 |
| U19 | MEM_MDQ_1 |
| U20 | MEM_MDQ_0 |
| V01 | EXT_AD_31 |
| V02 | EXT_AD_20 |
| V03 | EXT_AD_22 |
| V04 | EXT_AD_18 |
| V05 | PCI_FRAME |
| V06 | PCI_STOP |
| Y04 | EXT_AD_19 |
| Y05 | EXT_AD_17 |
| Y06 | PCI_IRDY |
| Y07 | PCI_PERR |
| Y08 | PCI_CBE_1 |
| Y09 | EXT_AD_12 |
| Y10 | EXT_AD_10 |
| Y11 | EXT_AD_7 |
| Y12 | EXT_AD_3 |

**Table 2-1. Signals by Ball/Pin (Sheet 4 of 4)**

| Ball/Pin | Pin Name |
|---|---|
| V16 | LP_CS5 |
| V17 | ATA_DRQ |
| V18 | TIMER_1 |
| V19 | I2C_0 |
| V20 | I2C_2 |
| W01 | EXT_AD_29 |
| W02 | EXT_AD_25 |
| W03 | EXT_AD_23 |
| W04 | EXT_AD_16 |
| W05 | PCI_TRDY |
| W06 | PCI_CBE_2 |
| W07 | PCI_DEVSEL |
| W08 | PCI_SERR |
| W09 | EXT_AD_14 |
| W10 | PCI_CBE_0 |
| W11 | EXT_AD_8 |
| W12 | EXT_AD_5 |
| W13 | EXT_AD_1 |
| W14 | LP_CS0 |
| W15 | LP_CS3 |
| W16 | LP_RW |
| W17 | ATA_IOW |
| W18 | ATA_IOCHRDY |
| W19 | I2C_1 |
| W20 | I2C_3 |
| Y01 | EXT_AD_27 |
| Y02 | PCI_CBE_3 |
| Y03 | EXT_AD_21 |

| Ball/Pin | Pin Name |
|---|---|
| Y13 | LP_TS |
| Y14 | LP_CS1 |
| Y15 | LP_CS4 |
| Y16 | ATA_ISOLATION |
| Y17 | ATA_IOR |
| Y18 | ATA_DACK |
| Y19 | ATA_INTRQ |
| Y20 | TIMER_0 |

**Table 2-2. Signals by Signal Name (Sheet 1 of 4)**

| Signal Name | Ball/Pin |
|---|---|
| ATA_DACK | Y18 |
| ATA_DRQ | V17 |
| ATA_INTRQ | Y19 |
| ATA_IOCHRDY | W18 |
| ATA_IOR | Y17 |
| ATA_IOW | W17 |
| ATA_ISOLATION | Y16 |
| LP_CS0 | W14 |
| LP_CS1 | Y14 |
| LP_CS2 | V15 |
| LP_CS3 | W15 |
| LP_CS4 | Y15 |
| LP_CS5 | V16 |
| ETH_0 | K01 |
| ETH_1 | K02 |
| ETH_2 | K03 |
| ETH_3 | J01 |
| ETH_4 | J02 |
| ETH_5 | L03 |
| ETH_6 | N02 |
| ETH_7 | N01 |
| ETH_8 | M03 |
| ETH_9 | L01 |
| ETH_10 | J03 |
| ETH_11 | L04 |
| ETH_12 | M02 |
| ETH_13 | M01 |
| ETH_14 | N04 |
| ETH_15 | N03 |
| ETH_16 | L02 |
| ETH_17 | J04 |
| EXT_AD_0 | V13 |
| EXT_AD_1 | W13 |
| EXT_AD_2 | V12 |
| EXT_AD_3 | Y12 |
| EXT_AD_4 | V11 |
| EXT_AD_5 | W12 |
| PSC6_3 | C13 |
| PSC6_1 | C11 |

| Signal Name | Ball/Pin |
|---|---|
| EXT_AD_6 | U11 |
| EXT_AD_7 | Y11 |
| EXT_AD_8 | W11 |
| EXT_AD_9 | V10 |
| EXT_AD_10 | Y10 |
| EXT_AD_11 | V09 |
| EXT_AD_12 | Y09 |
| EXT_AD_13 | V08 |
| EXT_AD_14 | W09 |
| EXT_AD_15 | U08 |
| EXT_AD_16 | W04 |
| EXT_AD_17 | Y05 |
| EXT_AD_18 | V04 |
| EXT_AD_19 | Y04 |
| EXT_AD_20 | V02 |
| EXT_AD_21 | Y03 |
| EXT_AD_22 | V03 |
| EXT_AD_23 | W03 |
| EXT_AD_24 | U03 |
| EXT_AD_25 | W02 |
| EXT_AD_26 | T02 |
| EXT_AD_27 | Y01 |
| EXT_AD_28 | T03 |
| EXT_AD_29 | W01 |
| EXT_AD_30 | R03 |
| EXT_AD_31 | V01 |
| GPIO_WKUP_6 | C15 |
| GPIO_WKUP_7 | C12 |
| CORE_PLL_AVDD | C08 |
| CORE_PLL_AVSS | NC (no connection) |
| HRESET | B13 |
| I2C_0 | V19 |
| I2C_1 | W19 |
| I2C_2 | V20 |
| I2C_3 | W20 |
| PSC6_0 | B12 |
| PSC6_2 | A12 |
| MEM_MBA_1 | A17 |
| MEM_MDQ_0 | U20 |

**Table 2-2. Signals by Signal Name (Sheet 2 of 4)**

| Signal Name | Ball/Pin |
|---|---|
| IRQ0 | P03 |
| IRQ1 | P01 |
| IRQ2 | P02 |
| IRQ3 | R01 |
| JTAG_TCK | B04 |
| JTAG_TDI | A03 |
| JTAG_TDO | A02 |
| JTAG_TMS | A04 |
| JTAG_TRST | B03 |
| LP_ACK | U14 |
| LP_ALE | V14 |
| LP_OE | D08 |
| LP_RW | W16 |
| LP_TS | Y13 |
| MEM_CAS | B19 |
| MEM_CLK_EN | F20 |
| MEM_CS_0 | B18 |
| MEM_DQM_0 | N19 |
| MEM_DQM_1 | H19 |
| MEM_DQM_2 | A20 |
| MEM_DQM_3 | L17 |
| MEM_MA_0 | C17 |
| MEM_MA_1 | A16 |
| MEM_MA_2 | B16 |
| MEM_MA_3 | C16 |
| MEM_MA_4 | B20 |
| MEM_MA_5 | C19 |
| MEM_MA_6 | C20 |
| MEM_MA_7 | D19 |
| MEM_MA_8 | D20 |
| MEM_MA_9 | E19 |
| MEM_MA_10 | B17 |
| MEM_MA_11 | E20 |
| MEM_MA_12 | F19 |
| MEM_MBA_0 | C18 |
| MEM_CLK | G19 |
| MEM_CLK | G20 |
| MEM_RAS | A18 |
| MEM_WE | A19 |
| PCI_CBE_0 | W10 |

| Signal Name | Ball/Pin |
|---|---|
| MEM_MDQ_1 | U19 |
| MEM_MDQ_2 | T20 |
| MEM_MDQ_3 | T19 |
| MEM_MDQ_4 | R20 |
| MEM_MDQ_5 | R19 |
| MEM_MDQ_6 | P20 |
| MEM_MDQ_7 | P19 |
| MEM_MDQ_8 | J19 |
| MEM_MDQ_9 | J20 |
| MEM_MDQ_10 | K19 |
| MEM_MDQ_11 | K20 |
| MEM_MDQ_12 | L19 |
| MEM_MDQ_13 | L20 |
| MEM_MDQ_14 | M19 |
| MEM_MDQ_15 | M20 |
| MEM_MDQ_16 | E18 |
| MEM_MDQ_17 | F18 |
| MEM_MDQ_18 | G17 |
| MEM_MDQ_19 | G18 |
| MEM_MDQ_20 | H18 |
| MEM_MDQ_21 | J18 |
| MEM_MDQ_22 | J17 |
| MEM_MDQ_23 | K18 |
| MEM_MDQ_24 | M18 |
| MEM_MDQ_25 | N17 |
| MEM_MDQ_26 | N18 |
| MEM_MDQ_27 | P18 |
| MEM_MDQ_28 | R17 |
| MEM_MDQ_29 | R18 |
| MEM_MDQ_30 | T18 |
| MEM_MDQ_31 | U18 |
| MEM_MDQS_0 | N20 |
| MEM_MDQS_1 | H20 |
| MEM_MDQS_2 | D18 |
| MEM_MDQS_3 | L18 |
| PSC3_5 | A06 |
| PSC3_6 | C05 |
| PSC3_7 | B05 |
| PSC3_8 | A05 |
| PSC3_9 | C04 |

**Table 2-2. Signals by Signal Name (Sheet 3 of 4)**

| Signal Name | Ball/Pin |
|---|---|
| PCI_CBE_1 | Y08 |
| PCI_CBE_2 | W06 |
| PCI_CBE_3 | Y02 |
| PCI_CLOCK | T01 |
| PCI_DEVSEL | W07 |
| PCI_FRAME | V05 |
| PCI_GNT | R04 |
| PCI_IDSEL | U02 |
| PCI_IRDY | Y06 |
| PCI_PAR | V07 |
| PCI_PERR | Y07 |
| PCI_REQ | U01 |
| PCI_RESET | R02 |
| PCI_SERR | W08 |
| PCI_STOP | V06 |
| PCI_TRDY | W05 |
| PORRESET | A13 |
| PSC1_0 | B11 |
| PSC1_1 | A11 |
| PSC1_2 | C10 |
| PSC1_3 | B10 |
| PSC1_4 | A10 |
| PSC2_0 | C09 |
| PSC2_1 | B09 |
| PSC2_2 | A09 |
| PSC2_3 | B08 |
| PSC2_4 | A08 |
| PSC3_0 | C07 |
| PSC3_1 | B07 |
| PSC3_2 | A07 |
| PSC3_3 | C06 |
| PSC3_4 | B06 |
| VDD_CORE | D10 |
| VDD_CORE | D11 |
| VDD_CORE | K04 |
| VDD_CORE | M04 |
| VDD_CORE | P04 |
| VDD_CORE | U07 |
| VDD_CORE | U12 |
| VDD_CORE | U15 |

| Signal Name | Ball/Pin |
|---|---|
| RTC_XTAL_IN | C02 |
| RTC_XTAL_OUT | C01 |
| SRESET | A14 |
| SYS_PLL_AVDD | B14 |
| SYS_PLL_AVSS | C14 |
| SYS_PLL_TPA | B15 |
| SYS_XTAL_IN | A15 |
| SYS_XTAL_OUT | D14 |
| TEST_MODE_0 | B02 |
| TEST_MODE_1 | A01 |
| TEST_SEL_0 | B01 |
| TEST_SEL_1 | C03 |
| TIMER_0 | Y20 |
| TIMER_1 | V18 |
| TIMER_2 | D03 |
| TIMER_3 | D02 |
| TIMER_4 | D01 |
| TIMER_5 | E03 |
| TIMER_6 | E02 |
| TIMER_7 | E01 |
| USB_0 | H01 |
| USB_1 | H02 |
| USB_2 | H03 |
| USB_3 | G01 |
| USB_4 | G02 |
| USB_5 | G03 |
| USB_6 | G04 |
| USB_7 | F01 |
| USB_8 | F02 |
| USB_9 | F03 |
| VDD_CORE | D05 |
| VSS_IO/CORE | J12 |
| VSS_IO/CORE | K09 |
| VSS_IO/CORE | K10 |
| VSS_IO/CORE | K11 |
| VSS_IO/CORE | K12 |
| VSS_IO/CORE | L09 |
| VSS_IO/CORE | L10 |
| VSS_IO/CORE | L11 |
| VSS_IO/CORE | L12 |

**Table 2-2. Signals by Signal Name (Sheet 4 of 4)**

| Signal Name | Ball/Pin |
|---|---|
| VDD_IO | D06 |
| VDD_IO | D09 |
| VDD_IO | E04 |
| VDD_IO | F04 |
| VDD_IO | H4 |
| VDD_IO | T4 |
| VDD_IO | U05 |
| VDD_IO | U06 |
| VDD_IO | U09 |
| VDD_IO | U10 |
| VDD_IO | U13 |
| VDD_IO | U16 |
| VDD_MEM_IO | D12 |
| VDD_MEM_IO | D13 |
| VDD_MEM_IO | D15 |
| VDD_MEM_IO | D17 |
| VDD_MEM_IO | E17 |
| VDD_MEM_IO | F17 |
| VDD_MEM_IO | H17 |
| VDD_MEM_IO | K17 |
| VDD_MEM_IO | M17 |
| VDD_MEM_IO | P17 |
| VDD_MEM_IO | T17 |
| VSS_IO/CORE | D04 |
| VSS_IO/CORE | D16 |
| VSS_IO/CORE | J09 |
| VSS_IO/CORE | J10 |
| VSS_IO/CORE | J11 |
| VSS_IO/CORE | M09 |
| VSS_IO/CORE | M10 |
| VSS_IO/CORE | M11 |
| VSS_IO/CORE | M12 |
| VSS_IO/CORE | U04 |
| VSS_IO/CORE | U17 |
| VDD_CORE | D07 |

**Table 2-3. LocalPlus Bus Address / Data Pin Assignments**

| MPC5200B LocaLPlus Bus Address / Data Pins | EXT_AD31 | EXT_AD30 | EXT_AD29 | EXT_AD28 | EXT_AD27 | EXT_AD26 | EXT_AD25 | EXT_AD24 | EXT_AD23 | EXT_AD22 | EXT_AD21 | EXT_AD20 | EXT_AD19 | EXT_AD18 | EXT_AD17 | EXT_AD16 | EXT_AD15 | EXT_AD14 | EXT_AD13 | EXT_AD12 | EXT_AD11 | EXT_AD10 | EXT_AD9 | EXT_AD8 | EXT_AD7 | EXT_AD6 | EXT_AD5 | EXT_AD4 | EXT_AD3 | EXT_AD2 | EXT_AD1 | EXT_AD0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **16 bit Adr, 16 bit Data** | D15 | D14 | D13 | D12 | D11 | D10 | D09 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | A15 | A14 | A13 | A12 | A11 | A10 | A9 | A8 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 |
| **24 bit Adr, 8 bit Data** | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | A23 | A22 | A21 | A20 | A19 | A18 | A17 | A16 | A15 | A14 | A13 | A12 | A11 | A10 | A9 | A8 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 |
| **Muxed modes** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **All Muxed mode Address tenures** | 0 | TS1ZE2 | TS1ZE1 | TS1ZE0 | 0 | BS1 | BS0 | A24 | A23 | A22 | A21 | A20 | A19 | A18 | A17 | A16 | A15 | A14 | A13 | A12 | A11 | A10 | A9 | A8 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 |
| **8 bit Data tenure** | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | |
| **16 bit Data tenure** | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D3 | D2 | D0 | | | | | | | | | | | | | | | | |
| **32 bit Data tenure** | D31 | D30 | D29 | D28 | D27 | D26 | D25 | D24 | D23 | D22 | D21 | D20 | D19 | D18 | D17 | D16 | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |

## Table 2-4. LocalPlus Pin Functions (Sheet 1 of 3)

| Pin Name | BALL | LocalPlus Non-mux | | LocalPlus MULTIPLEXED BUS | | | | PCI BUS | | | | ATA | MOST | Large Flash | RESET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Addr /Data 24/8 | Addr /Data 16/16 | Address Phase | 32-bit Data Phase | 16-bit Data Phase | 8-bit Data Phase | PCI Address Phase | 32-bit Data Phase | 16-bit Data Phase | 8-bit Data Phase | | | | |
| EXT_AD_31 | V01 | D7 | D15 | 0 | D31 | D15 | D7 | A31 | D31 | 0 | 0 | | D31 | D15 | |
| EXT_AD_30 | R03 | D6 | D14 | TSIZ0 | D30 | D14 | D6 | A30 | D30 | 0 | 0 | | D30 | D14 | |
| EXT_AD_29 | W01 | D5 | D13 | TSIZ1 | D29 | D13 | D5 | A29 | D29 | 0 | 0 | | D29 | D13 | |
| EXT_AD_28 | T03 | D4 | D12 | TSIZ2 | D28 | D12 | D4 | A28 | D28 | 0 | 0 | | D28 | D12 | |
| EXT_AD_27 | Y01 | D3 | D11 | 0 | D27 | D11 | D3 | A27 | D27 | 0 | 0 | | D27 | D11 | |
| EXT_AD_26 | T02 | D2 | D10 | BS1 | D26 | D10 | D2 | A26 | D26 | 0 | 0 | | D26 | D10 | |
| EXT_AD_25 | W02 | D1 | D9 | BS0 | D25 | D9 | D1 | A25 | D25 | 0 | 0 | | D25 | D9 | |
| EXT_AD_24 | U03 | D0 | D8 | A24 | D24 | D8 | D0 | A24 | D24 | 0 | 0 | | D24 | D8 | |
| EXT_AD_23 | W03 | A23 | D7 | A23 | D23 | D7 | 0 | A23 | D23 | 0 | 0 | | D23 | D7 | |
| EXT_AD_22 | V03 | A22 | D6 | A22 | D22 | D6 | 0 | A22 | D22 | 0 | 0 | | D22 | D6 | |
| EXT_AD_21 | Y03 | A21 | D5 | A21 | D21 | D5 | 0 | A21 | D21 | 0 | 0 | | D21 | D5 | |
| EXT_AD_20 | V02 | A20 | D4 | A20 | D20 | D4 | 0 | A20 | D20 | 0 | 0 | | D20 | D4 | |
| EXT_AD_19 | Y04 | A19 | D3 | A19 | D19 | D3 | 0 | A19 | D19 | 0 | 0 | | D19 | D3 | |
| EXT_AD_18 | V04 | A18 | D2 | A18 | D18 | D2 | 0 | A18 | D18 | 0 | 0 | SA_2 | D18 | D2 | |
| EXT_AD_17 | Y05 | A17 | D1 | A17 | D17 | D1 | 0 | A17 | D17 | 0 | 0 | SA_1 | D17 | D1 | |
| EXT_AD_16 | W04 | A16 | D0 | A16 | D16 | D0 | 0 | A16 | D16 | 0 | 0 | SA_0 | D16 | D0 | |
| EXT_AD_15 | U08 | A15 | A15 | A15 | D15 | 0 | 0 | A15 | D15 | D15 | 0 | D15 | D15 | A15 | |
| EXT_AD_14 | W09 | A14 | A14 | A14 | D14 | 0 | 0 | A14 | D14 | D14 | 0 | D14 | D14 | A14 | |
| EXT_AD_13 | V08 | A13 | A13 | A13 | D13 | 0 | 0 | A13 | D13 | D13 | 0 | D13 | D13 | A13 | |
| EXT_AD_12 | Y09 | A12 | A12 | A12 | D12 | 0 | 0 | A12 | D12 | D12 | 0 | D12 | D12 | A12 | |
| EXT_AD_11 | V09 | A11 | A11 | A11 | D11 | 0 | 0 | A11 | D11 | D11 | 0 | D11 | D11 | A11 | |
| EXT_AD_10 | Y10 | A10 | A10 | A10 | D10 | 0 | 0 | A10 | D10 | D10 | 0 | D10 | D10 | A10 | |
| EXT_AD_9 | V10 | A9 | A9 | A9 | D9 | 0 | 0 | A9 | D9 | D9 | 0 | D9 | D9 | A9 | |
| EXT_AD_8 | W11 | A8 | A8 | A8 | D8 | 0 | 0 | A8 | D8 | D8 | 0 | D8 | D8 | A8 | |
| EXT_AD_7 | Y11 | A7 | A7 | A7 | D7 | 0 | 0 | A7 | D7 | D7 | D7 | D7 | D7 | A7 | |
| EXT_AD_6 | U11 | A6 | A6 | A6 | D6 | 0 | 0 | A6 | D6 | D6 | D6 | D6 | D6 | A6 | |
| EXT_AD_5 | W12 | A5 | A5 | A5 | D5 | 0 | 0 | A5 | D5 | D5 | D5 | D5 | D5 | A5 | |
| EXT_AD_4 | V11 | A4 | A4 | A4 | D4 | 0 | 0 | A4 | D4 | D4 | D4 | D4 | D4 | A4 | |
| EXT_AD_3 | Y12 | A3 | A3 | A3 | D3 | 0 | 0 | A3 | D3 | D3 | D3 | D3 | D3 | A3 | |
| EXT_AD_2 | V12 | A2 | A2 | A2 | D2 | 0 | 0 | A2 | D2 | D2 | D2 | D2 | D2 | A2 | |
| EXT_AD_1 | W13 | A1 | A1 | A1 | D1 | 0 | 0 | A1 | D1 | D1 | D1 | D1 | D1 | A1 | |
| EXT_AD_0 | V13 | A0 | A0 | A0 | D0 | 0 | 0 | A0 | D0 | D0 | D0 | D0 | D0 | A0 | |

## Table 2-4. LocalPlus Pin Functions (Sheet 2 of 3)

| Pin Name | BALL | LocalPlus Non-mux | | LocalPlus MULTIPLEXED BUS | | | | PCI BUS | | | | ATA | MOST | Large Flash | RESET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Addr /Data 24/8 | Addr /Data 16/16 | Address Phase | 32-bit Data Phase | 16-bit Data Phase | 8-bit Data Phase | PCI Address Phase | 32-bit Data Phase | 16-bit Data Phase | 8-bit Data Phase | | | | |
| **PCI Dedicated Signals** | | | | | | | | | | | | | | | |
| PCI_PAR | V07 | | | | | | | PCI_PAR | | | | | A0 | A16 | |
| PCI_CBE_0 | W10 | | | | | | | PCI_CBE_0 | | | | | A1 | A17 | |
| PCI_CBE_1 | Y08 | | | | | | | PCI_CBE_1 | | | | | A2 | A18 | |
| PCI_CBE_2 | W06 | | | | | | | PCI_CBE_2 | | | | | A3 | A19 | |
| PCI_CBE_3 | Y02 | | | | | | | PCI_CBE_3 | | | | | A4 | A20 | |
| PCI_TRDY | W05 | | | | | | | PCI_TRDY | | | | | A5 | A21 | |
| PCI_IRDY | Y06 | | | | | | | PCI_IRDY | | | | | A6 | A22 | |
| PCI_STOP | V06 | | | | | | | PCI_STOP | | | | | A7 | A23 | |
| PCI_DEVSEL | W07 | | | | | | | PCI_DEVSEL | | | | | A8 | A24 | |
| PCI_FRAME | V05 | | | | | | | PCI_FRAME | | | | | A9 | A25 | |
| PCI_SERR | W08 | | | | | | | PCI_SERR | | | | | A10 | Note 1 | |
| PCI_PERR | Y07 | | | | | | | PCI_PERR | | | | | A11 | Note 1 | |
| PCI_IDSEL | U02 | | | | | | | PCI_IDSEL | | | | | A12 | Note 1 | |
| PCI_REQ | U01 | | | | | | | PCI_REQ | | | | | A13 | Note 1 | |
| PCI_GNT | R04 | | | | | | | PCI_GNT | | | | | A14 | Note 1 | |
| PCI_CL0CK | T01 | CLK OUT | CLK OUT | CLK OUT | CLK OUT | CLK OUT | CLK OUT | Same as PCI_CLOCK | | | | | CLK OUT | CLK OUT | |
| PCI_RESET | R02 | | | | | | | PCI_RESET | | | | | A15 | Note 1 | |
| **ATA Dedicated Signals** | | | | | | | | | | | | | | | |
| ATA_DRQ | V17 | | | | | | | | | | | ATA_DRQ | A16 | | |
| ATA_DACK | Y18 | | | | | | | | | | | ATA_DACK | A17 | | RST_CFG0 |
| ATA_IOR | Y17 | | | | | | | | | | | ATA_IOR | A18 | | RST_CFG1 |
| ATA_IOW | W17 | | | | | | | | | | | ATA_IOW | A19 | | RST_CFG2 |
| ATA_IOCHRDY | W18 | | | | | | | | | | | ATA_IOCHRDY | A20 | | |
| ATA_INTRQ | Y19 | | | | | | | | | | | ATA_INTRQ | A21 | | |
| ATA_ISOLATION | Y16 | | | | | | | | | | | ATA_ISOLATION | A22 | | |
| **LocalPlus Dedicated Signals** | | | | | | | | | | | | | | | |
| LP_RW | W16 | LP_RW | | | | | | | | | | | LP_RW | | RST_CFG3 |
| LP_ALE | V14 | | | LP_ALE | | | | | | | | | A23 | | RST_CFG4 |
| LP_ACK | U14 | LP_ACK | | | | | | | | | | | LP_ACK, Note 2 | | |
| LP_TS | Y13 | | | LP_TS | | | | | | | | | LP_TS | | RST_CFG5 |
| LP_OE | D08 | LP_OE | | | | | | | | | | | LP_OE | | |
| LP_CS0 | W14 | CS_0 / CS_BOOT | | | | | | | | | | | CS_0 / CS_BOOT | | |
| LP_CS1 | Y14 | CS_1 | | | | | | | | | | | CS_1 | | |

**Table 2-4. LocalPlus Pin Functions (Sheet 3 of 3)**

| Pin Name | BALL | LocalPlus Non-mux | | LocalPlus MULTIPLEXED BUS | | | | PCI BUS | | | | ATA | MOST | Large Flash | RESET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Addr /Data 24/8 | Addr /Data 16/16 | Address Phase | 32-bit Data Phase | 16-bit Data Phase | 8-bit Data Phase | PCI Address Phase | 32-bit Data Phase | 16-bit Data Phase | 8-bit Data Phase | | | | |
| LP_CS2 | V15 | CS_2 | | | | | | | | | | | CS_2 | | |
| LP_CS3 | W15 | CS_3 | | | | | | | | | | | CS_3 | | |
| LP_CS4 | Y15 | CS_4 | | | | | | | | | | ATA_CS_0 | CS_4 | | |
| LP_CS5 | V16 | CS_5 | | | | | | | | | | ATA_CS_1 | CS_5 | | |
| **PSC 3 Dedicated Signals** | | | | | | | | | | | | | | | |
| PSC3_4 | B06 | CS_6 | | | | | | | | | | | CS_6 | | |
| PSC3_5 | A06 | CS_7 | | | | | | | | | | | CS_7 | | |
| **GPIO_WKUP Dedicated Signals** | | | | | | | | | | | | | | | |
| GPIO_WKUP_7 | C12 | | | | | | | | | | | | TSIZ1 | | |
| **JTAG Access Dedicated Signals** | | | | | | | | | | | | | | | |
| TEST_SEL_1 | C03 | | | | | | | | | | | | TSIZ2 | | |

1. The PCI signals, which are not used as address in Large Flash mode, are drive low during a Large Flash access.
2. For a burst transaction LP_ACK signal indicates the burst

.

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 1 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_31 Ball V01** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>logic 0<br>D7<br>D15<br>D31 | hi - z | <br>logic 0<br>LocalPlus Data Bit 7<br>LocalPlus Data Bit 15<br>LocalPlus Data Bit 31 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D15<br>D7 | hi - z | logic 0<br>LocalPlus Data Bit 15 |
| LFLASH | D15 | hi - z | Large Flash Data Bit D15 |
| MOST Graphics | D31 | hi - z | MOST Graphics Data Bit D31 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A31<br>logic 0<br>logic 0<br>D31 | hi - z | <br>PCI Address Bit A31<br>logic 0<br>logic 0<br>PCI Data Bit 31 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 2 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_30 Ball R03** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>TSIZE0<br>D6<br>D14<br>D30 | hi - z | <br>LocalPlus TSIZE0<br>LocalPlus Data Bit 6<br>LocalPlus Data Bit 14<br>LocalPlus Data Bit 30 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D14<br>D6 | hi - z | <br>LocalPlus Data Bit 14<br>LocalPlus Data Bit 6 |
| LFLASH | D14 | hi - z | Large Flash Data Bit D14 |
| MOST Graphics | D30 | hi - z | MOST Graphics Data Bit D30 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A30<br>logic 0<br>logic 0<br>D30 | hi - z | <br>PCI Address Bit A30<br>logic 0<br>logic 0<br>PCI Data Bit 30 |
| **Pin EXT_AD_29 Ball W01** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>TSIZE1<br>D5<br>D13<br>D29 | hi - z | <br>LocalPlus TSIZE1<br>LocalPlus Data Bit 5<br>LocalPlus Data Bit 13<br>LocalPlus Data Bit 29 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D13<br>D5 | hi - z | <br>LocalPlus Data Bit 13<br>LocalPlus Data Bit 5 |
| LFLASH | D13 | hi - z | Large Flash Data Bit D13 |
| MOST Graphics | D29 | hi - z | MOST Graphics Data Bit D29 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A31<br>logic 0<br>logic 0<br>D29 | hi - z | <br>PCI Address Bit A29<br>logic 0<br>logic 0<br>PCI Data Bit 29 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 3 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_28 Ball T03** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>TSIZE2<br>D4<br>D12<br>D28 | hi - z | <br>TSIZE2<br>LocalPlus Data Bit 4<br>LocalPlus Data Bit 12<br>LocalPlus Data Bit 28 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D12<br>D4 | hi - z | <br>LocalPlus Data Bit 12<br>LocalPlus Data Bit 4 |
| LFLASH | D12 | hi - z | Large Flash Data Bit D12 |
| MOST Graphics | D28 | hi - z | MOST Graphics Data Bit D28 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A28<br>logic 0<br>logic 0<br>D28 | hi - z | <br>PCI Address Bit A28<br>logic 0<br>logic 0<br>PCI Data Bit 28 |
| **Pin EXT_AD_27 Ball Y01** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>logic 0<br>D3<br>D11<br>D27 | hi - z | <br>logic 0<br>LocalPlus Data Bit 3<br>LocalPlus Data Bit 11<br>LocalPlus Data Bit 27 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D11<br>D3 | hi - z | <br>LocalPlus Data Bit 11<br>LocalPlus Data Bit 3 |
| LFLASH | D11 | hi - z | Large Flash Data Bit D11 |
| MOST Graphics | D27 | hi - z | MOST Graphics Data Bit D27 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A27<br>logic 0<br>logic 0<br>D27 | hi - z | <br>PCI Address Bit A27<br>logic 0<br>logic 0<br>PCI Data Bit 27 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 4 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_26 Ball T02** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>BS1<br>D2<br>D10<br>D26 | hi - z | <br>LocalPlus BS1<br>LocalPlus Data Bit 2<br>LocalPlus Data Bit 10<br>LocalPlus Data Bit 26 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D10<br>D2 | hi - z | <br>LocalPlus Data Bit 10<br>LocalPlus Data Bit 2 |
| LFLASH | D10 | hi - z | Large Flash Data Bit D10 |
| MOST Graphics | D26 | hi - z | MOST Graphics Data Bit D26 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A26<br>logic 0<br>logic 0<br>D26 | hi - z | <br>PCI Address Bit A26<br>logic 0<br>logic 0<br>PCI Data Bit 26 |
| **Pin EXT_AD_25 Ball W02** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>BS0<br>D1<br>D9<br>D25 | hi - z | <br>BS0<br>LocalPlus Data Bit 1<br>LocalPlus Data Bit 9<br>LocalPlus Data Bit 25 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D9<br>D1 | hi - z | <br>LocalPlus Data Bit 9<br>LocalPlus Data Bit 1 |
| LFLASH | D9 | hi - z | Large Flash Data Bit D9 |
| MOST Graphics | D25 | hi - z | MOST Graphics Data Bit D25 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A25<br>logic 0<br>logic 0<br>D25 | hi - z | <br>PCI Address Bit A25<br>logic 0<br>logic 0<br>PCI Data Bit 25 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 5 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_24 Ball U03** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A24<br>D0<br>D8<br>D24 | hi - z | <br>LocalPlus Address Bit 24<br>LocalPlus Data Bit 0<br>LocalPlus Data Bit 8<br>LocalPlus Data Bit 24 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D8<br>D0 | hi - z | <br>LocalPlus Data Bit 8<br>LocalPlus Data Bit 0 |
| LFLASH | D8 | hi - z | Large Flash Data Bit D8 |
| MOST Graphics | D24 | hi - z | MOST Graphics Data Bit D24 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A24<br>logic 0<br>logic 0<br>D24 | hi - z | <br>PCI Address Bit A24<br>logic 0<br>logic 0<br>PCI Data Bit 24 |
| **Pin EXT_AD_23 Ball W03** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A23<br>logic 0<br>D7<br>D23 | hi - z | <br>Local Address Bit A23<br>logic 0<br>LocalPlus Data Bit 7<br>LocalPlus Data Bit 23 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D7<br>A23 | hi - z | <br>LocalPlus Data Bit 7<br>LocalPlus Address Bit A23 |
| LFLASH | D7 | hi - z | Large Flash Data Bit D7 |
| MOST Graphics | D23 | hi - z | MOST Graphics Data Bit D23 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A23<br>logic 0<br>logic 0<br>D23 | hi - z | <br>PCI Address Bit A23<br>logic 0<br>logic 0<br>PCI Data Bit D23 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 6 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_22 Ball V03** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A22<br>logic 0<br>D6<br>D22 | hi - z | <br>LocalPlus Address Bit A22<br>logic 0<br>LocalPlus Data Bit 6<br>LocalPlus Data Bit D22 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D6<br>A22 | hi - z | <br>LocalPlus Data Bit D6<br>LocalPlus Address Bit A22 |
| LFLASH | D6 | hi - z | Large Flash Data Bit D6 |
| MOST Graphics | D22 | hi - z | MOST Graphics Data Bit D22 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A22<br>logic 0<br>logic 0<br>D22 | hi - z | <br>PCI Address Bit A22<br>logic 0<br>logic 0<br>PCI Data Bit D22 |
| **Pin EXT_AD_21 Ball Y03** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A21<br>logic 0<br>D5<br>D21 | hi - z | <br>LocalPlus Address Bit A21<br>logic 0<br>LocalPlus Data Bit 5<br>LocalPlus Data Bit D21 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D5<br>A21 | hi - z | <br>LocalPlus Data Bit D5<br>LocalPlus Address Bit A21 |
| LFLASH | D5 | hi - z | Large Flash Data Bit D5 |
| MOST Graphics | D21 | hi - z | MOST Graphics Data Bit D21 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A21<br>logic 0<br>logic 0<br>D21 | hi - z | <br>PCI Address Bit A21<br>logic 0<br>logic 0<br>PCI Data Bit D21 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 7 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_20 Ball V02** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A20<br>logic 0<br>D4<br>D20 | hi - z | <br>LocalPlus Address Bit A20<br>logic 0<br>LocalPlus Data Bit 4<br>LocalPlus Data Bit D20 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D4<br>A20 | hi - z | <br>LocalPlus Data Bit D4<br>LocalPlus Address Bit A20 |
| LFLASH | D4 | hi - z | Large Flash Data Bit D4 |
| MOST Graphics | D20 | hi - z | MOST Graphics Data Bit D20 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A20<br>logic 0<br>logic 0<br>D20 | hi - z | <br>PCI Address Bit A20<br>logic 0<br>logic 0<br>PCI Data Bit D20 |
| **Pin EXT_AD_19 Ball Y04** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A19<br>logic 0<br>D3<br>D19 | hi - z | <br>LocalPlus Address Bit A19<br>logic 0<br>LocalPlus Data Bit 3<br>LocalPlus Data Bit D19 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D3<br>A19 | hi - z | <br>LocalPlus Data Bit D3<br>LocalPlus Address Bit A19 |
| LFLASH | D3 | hi - z | Large Flash Data Bit D3 |
| MOST Graphics | D19 | hi - z | MOST Graphics Data Bit D19 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A19<br>logic 0<br>logic 0<br>D19 | hi - z | <br>PCI Address Bit A19<br>logic 0<br>logic 0<br>PCI Data Bit D19 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 8 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_18 Ball V04** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A18<br>logic 0<br>D2<br>D18 | hi - z | <br>LocalPlus Address Bit A18<br>logic 0<br>LocalPlus Data Bit 2<br>LocalPlus Data Bit D18 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D2<br>A18 | hi - z | <br>LocalPlus Data Bit D2<br>LocalPlus Address Bit A18 |
| LFLASH | D2 | hi - z | Large Flash Data Bit D2 |
| MOST Graphics | D18 | hi - z | MOST Graphics Data Bit D18 |
| ATA | ATA_SA_2 | hi - z | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A18<br>logic 0<br>logic 0<br>D18 | hi - z | <br>PCI Address Bit A18<br>logic 0<br>logic 0<br>PCI Data Bit D18 |
| **Pin EXT_AD_17 Ball Y05** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A17<br>logic 0<br>D1<br>D17 | hi - z | <br>LocalPlus Address Bit A17<br>logic 0<br>LocalPlus Data Bit 1<br>LocalPlus Data Bit D17 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D1<br>A17 | hi - z | <br>LocalPlus Data Bit D1<br>LocalPlus Address Bit A17 |
| LFLASH | D1 | hi - z | Large Flash Data Bit D1 |
| MOST Graphics | D17 | hi - z | MOST Graphics Data Bit D17 |
| ATA | — | — | — |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A17<br>logic 0<br>logic 0<br>D17 | hi - z | <br>PCI Address Bit A17<br>logic 0<br>logic 0<br>PCI Data Bit D17 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 9 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_16 Ball W04** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A16<br>logic 0<br>D0<br>D16 | hi - z | <br>LocalPlus Address Bit A16<br>logic 0<br>LocalPlus Data Bit 0<br>LocalPlus Data Bit D16 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>D0<br>A16 | hi - z | <br>LocalPlus Data Bit D0<br>LocalPlus Address Bit A16 |
| LFLASH | D0 | hi - z | Large Flash Data Bit D0 |
| MOST Graphics | D16 | hi - z | MOST Graphics Data Bit D16 |
| ATA | ATA_SA_0 | hi - z | ATA_SA_0 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A16<br>logic 0<br>logic 0<br>D16 | hi - z | <br>PCI Address Bit A16<br>logic 0<br>logic 0<br>PCI Data Bit D16 |
| **Pin EXT_AD_15 Ball U08** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A15<br>logic 0<br>logic 0<br>D15 | hi - z | <br>LocalPlus Address Bit A15<br>logic 0<br>logic 0<br>LocalPlus Data Bit D15 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A15<br>A15 | hi - z | <br>LocalPlus Address Bit A15<br>LocalPlus Address Bit A15 |
| LFLASH | A15 | hi - z | Large Flash Address Bit A15 |
| MOST Graphics | D15 | hi - z | MOST Graphics Data Bit D15 |
| ATA | ATA_DATA_15 | hi - z | ATA Data Bit 15 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A15<br>logic 0<br>D15<br>D15 | hi - z | <br>PCI Address Bit A15<br>logic 0<br>PCI Data Bit D15<br>PCI Data Bit D15 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 10 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_14 Ball W09** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A14<br>logic 0<br>logic 0<br>D14 | hi - z | <br>LocalPlus Address Bit A14<br>logic 0<br>logic 0<br>LocalPlus Data Bit D14 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A14<br>A14 | hi - z | <br>LocalPlus Address Bit A14<br>LocalPlus Address Bit A14 |
| LFLASH | A14 | hi - z | Large Flash Address Bit A14 |
| MOST Graphics | D14 | hi - z | MOST Graphics Data Bit D14 |
| ATA | ATA_DATA_14 | hi - z | ATA_DATA_14 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A14<br>logic 0<br>D14<br>D14 | hi - z | <br>PCI Address Bit A14<br>logic 0<br>PCI Data Bit D14<br>PCI Data Bit D14 |
| **Pin EXT_AD_13 Ball V08** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A13<br>logic 0<br>logic 03<br>D13 | hi - z | <br>LocalPlus Address Bit A13<br>logic 0<br>logic 0<br>LocalPlus Data Bit D13 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A13<br>A13 | hi - z | <br>LocalPlus Address Bit A13<br>LocalPlus Address Bit A13 |
| LFLASH | A13 | hi - z | Large Flash Address Bit A13 |
| MOST Graphics | D13 | hi - z | MOST Graphics Data Bit D13 |
| ATA | ATA_DATA_13 | hi - z | ATA Data Bit D13 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A13<br>logic 0<br>D13<br>D13 | hi - z | <br>PCI Address Bit A13<br>logic 0<br>PCI Data Bit D13<br>PCI Data Bit D13 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 11 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_12 Ball Y09** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A12<br>logic 0<br>logic 0<br>D12 | hi - z | <br>LocalPlus Address Bit A12<br>logic 0<br>logic 0<br>LocalPlus Data Bit D12 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A12<br>A12 | hi - z | <br>LocalPlus Address Bit A12<br>LocalPlus Address Bit A12 |
| LFLASH | A12 | hi - z | Large Flash Address Bit A12 |
| MOST Graphics | D12 | hi - z | MOST Graphics Data Bit D12 |
| ATA | ATA_DATA_12 | hi - z | ATA_DATA_12 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A12<br>logic 0<br>D12<br>D12 | hi - z | <br>PCI Address Bit A12<br>logic 0<br>PCI Data Bit D12<br>PCI Data Bit D12 |
| **Pin EXT_AD_11 Ball V09** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A11<br>logic 0<br>logic 0<br>D11 | hi - z | <br>LocalPlus Address Bit A11<br>logic 0<br>logic 0<br>LocalPlus Data Bit D11 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A11<br>A11 | hi - z | <br>LocalPlus Address Bit A11<br>LocalPlus Address Bit A11 |
| LFLASH | A11 | hi - z | Large Flash Address Bit A11 |
| MOST Graphics | D11 | hi - z | MOST Graphics Data Bit D11 |
| ATA | ATA_DATA_11 | hi - z | ATA_DATA_11 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A11<br>logic 0<br>D11<br>D11 | hi - z | <br>PCI Address Bit A11<br>logic 0<br>PCI Data Bit D11<br>PCI Data Bit D11 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 12 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_10 Ball Y10** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A10<br>logic 0<br>logic 0<br>D10 | hi - z | <br>LocalPlus Address Bit A10<br>logic 0<br>logic 0<br>LocalPlus Data Bit D10 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A10<br>A10 | hi - z | <br>LocalPlus Address Bit A10<br>LocalPlus Address Bit A10 |
| LFLASH | A10 | hi - z | Large Flash Address Bit A10 |
| MOST Graphics | D10 | hi - z | MOST Graphics Data Bit D10 |
| ATA | ATA_DATA_10 | hi - z | ATA_DATA_10 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A10<br>logic 0<br>D10<br>D10 | hi - z | <br>PCI Address Bit A10<br>logic 0<br>PCI Data Bit D10<br>PCI Data Bit D10 |
| **Pin EXT_AD_9 Ball V10** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A9<br>logic 0<br>logic 0<br>D9 | hi - z | <br>LocalPlus Address Bit A9<br>logic 0<br>logic 0<br>LocalPlus Data Bit D9 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A9<br>A9 | hi - z | <br>LocalPlus Address Bit A9<br>LocalPlus Address Bit A9 |
| LFLASH | A9 | hi - z | Large Flash Address Bit A9 |
| MOST Graphics | D9 | hi - z | MOST Graphics Data Bit D22 |
| ATA | ATA_DATA_9 | hi - z | ATA_DATA_9 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A9<br>logic 0<br>D9<br>D9 | hi - z | <br>PCI Address Bit A9<br>logic 0<br>PCI Data Bit D9<br>PCI Data Bit D9 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 13 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_8 Ball W11** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A8<br>logic 0<br>logic 0<br>D8 | hi - z | <br>LocalPlus Address Bit A8<br>logic 0<br>logic 0<br>LocalPlus Data Bit D8 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A8<br>A8 | hi - z | <br>LocalPlus Address Bit A8<br>LocalPlus Address Bit A8 |
| LFLASH | A8 | hi - z | Large Flash Address Bit A8 |
| MOST Graphics | D8 | hi - z | MOST Graphics Data Bit D8 |
| ATA | ATA_DATA_8 | hi - z | ATA_DATA_8 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A8<br>logic 0<br>D8<br>D8 | hi - z | <br>PCI Address Bit A8<br>logic 0<br>PCI Data Bit D8<br>PCI Data Bit D8 |
| **Pin EXT_AD_7 Ball Y11** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A7<br>logic 0<br>logic 0<br>D7 | hi - z | <br>LocalPlus Address Bit A7<br>logic 0<br>logic 0<br>LocalPlus Data Bit D7 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A7<br>A7 | hi - z | <br>LocalPlus Address Bit A7<br>LocalPlus Address Bit A7 |
| LFLASH | A7 | hi - z | Large Flash Address Bit A7 |
| MOST Graphics | D7 | hi - z | MOST Graphics Data Bit D7 |
| ATA | ATA_DATA_7 | hi - z | ATA_DATA_7 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A7<br>D7<br>D7<br>D7 | hi - z | <br>PCI Address Bit A7<br>PCI Data Bit D7<br>PCI Data Bit D7<br>PCI Data Bit D7 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 14 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_6 Ball U11** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A6<br>logic 0<br>logic 0<br>D6 | hi - z | <br>LocalPlus Address Bit A6<br>logic 0<br>logic 0<br>LocalPlus Data Bit D6 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A6<br>A6 | hi - z | <br>LocalPlus Address Bit A6<br>LocalPlus Address Bit A6 |
| LFLASH | A6 | hi - z | Large Flash Address Bit A6 |
| MOST Graphics | D6 | hi - z | MOST Graphics Data Bit D6 |
| ATA | ATA_DATA_6 | hi - z | ATA_DATA_6 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A6<br>D6<br>D6<br>D6 | hi - z | <br>PCI Address Bit A6<br>PCI Data Bit D6<br>PCI Data Bit D6<br>PCI Data Bit D6 |
| **Pin EXT_AD_5 Ball W12** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A5<br>logic 0<br>logic 0<br>D5 | hi - z | <br>LocalPlus Address Bit A5<br>logic 0<br>logic 0<br>LocalPlus Data Bit D5 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A5<br>A5 | hi - z | <br>LocalPlus Address Bit A5<br>LocalPlus Address Bit A5 |
| LFLASH | A5 | hi - z | Large Flash Address Bit A5 |
| MOST Graphics | D5 | hi - z | MOST Graphics Data Bit D5 |
| ATA | ATA_DATA_5 | hi - z | ATA_DATA_5 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A5<br>D5<br>D5<br>D5 | hi - z | <br>PCI Address Bit A5<br>PCI Data Bit D5<br>PCI Data Bit D5<br>PCI Data Bit D5 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 15 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_4 Ball V11** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A4<br>logic 0<br>logic 0<br>D4 | hi - z | <br>LocalPlus Address Bit A4<br>logic 0<br>logic 0<br>LocalPlus Data Bit D4 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A4<br>A4 | hi - z | <br>LocalPlus Address Bit A4<br>LocalPlus Address Bit A4 |
| LFLASH | A4 | hi - z | Large Flash Address Bit A4 |
| MOST Graphics | D4 | hi - z | MOST Graphics Data Bit D4 |
| ATA | ATA_DATA_4 | hi - z | ATA_DATA_4 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A4<br>D4<br>D4<br>D4 | hi - z | <br>PCI Address Bit A4<br>PCI Data Bit D4<br>PCI Data Bit D4<br>PCI Data Bit D4 |
| **Pin EXT_AD_3 Ball Y12** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A3<br>logic 0<br>logic 0<br>D3 | hi - z | <br>LocalPlus Address Bit A3<br>logic 0<br>logic 0<br>LocalPlus Data Bit D3 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A3<br>A3 | hi - z | <br>LocalPlus Address Bit A3<br>LocalPlus Address Bit A3 |
| LFLASH | A3 | hi - z | Large Flash Address Bit A3 |
| MOST Graphics | D3 | hi - z | MOST Graphics Data Bit D3 |
| ATA | ATA_DATA_3 | hi - z | ATA_DATA_3 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A3<br>D3<br>D3<br>D3 | hi - z | <br>PCI Address Bit A3<br>PCI Data Bit D3<br>PCI Data Bit D3<br>PCI Data Bit D3 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 16 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_2 Ball V12** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A2<br>logic 0<br>logic 0<br>D2 | hi - z | <br>LocalPlus Address Bit A2<br>logic 0<br>logic 0<br>LocalPlus Data Bit D2 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A2<br>A2 | hi - z | <br>LocalPlus Address Bit A2<br>LocalPlus Address Bit A2 |
| LFLASH | A2 | hi - z | Large Flash Address Bit A2 |
| MOST Graphics | D2 | hi - z | MOST Graphics Data Bit D2 |
| ATA | ATA_DATA_2 | hi - z | ATA_DATA_2 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A2<br>D2<br>D2<br>D2 | hi - z | <br>PCI Address Bit A2<br>PCI Data Bit D2<br>PCI Data Bit D2<br>PCI Data Bit D2 |
| **Pin EXT_AD_1 Ball W13** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A1<br>logic 0<br>logic 0<br>D1 | hi - z | <br>LocalPlus Address Bit A1<br>logic 0<br>logic 0<br>LocalPlus Data Bit D1 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A1<br>A1 | hi - z | <br>LocalPlus Address Bit A1<br>LocalPlus Address Bit A1 |
| LFLASH | A1 | hi - z | Large Flash Address Bit A1 |
| MOST Graphics | D1 | hi - z | MOST Graphics Data Bit D1 |
| ATA | ATA_DATA_1 | hi - z | ATA_DATA_1 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A1<br>D1<br>D1<br>D1 | hi - z | <br>PCI Address Bit A1<br>PCI Data Bit D1<br>PCI Data Bit D1<br>PCI Data Bit D1 |

**Table 2-5. LocalPlus Bus Address / Data Signals (Sheet 17 of 17)**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin EXT_AD_0 Ball V13** | | | |
| LocalPlus Bus multiplexed mode<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A0<br>logic 0<br>logic 0<br>D0 | hi - z | <br>LocalPlus Address Bit A0<br>logic 0<br>logic 0<br>LocalPlus Data Bit D0 |
| LocalPlus non-mux<br>16-bit addr/16-bit data<br>24-bit addr/8-bit data | <br>A0<br>A0 | hi - z | <br>LocalPlus Address Bit A0<br>LocalPlus Address Bit A0 |
| LFLASH | A0 | hi - z | Large Flash Address Bit A0 |
| MOST Graphics | D0 | hi - z | MOST Graphics Data Bit D0 |
| ATA | ATA_DATA_0 | hi - z | ATA_DATA_0 |
| PCI<br>Address Phase<br>8-Bit Data Phase<br>16-Bit Data Phase<br>32-Bit Data Phase | <br>A0<br>logic 0<br>logic 0<br>D0 | hi - z | <br>PCI Address Bit A0<br>PCI Data Bit 0<br>PCI Data Bit 0<br>PCI Data Bit D0 |

**Table 2-6. PCI Dedicated Signals**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PCI_PAR Ball V07** | | | |
| PCI | PCI_PAR | logic 1 | PCI Bus Parity |
| LFLASH | A16 | logic 1 | Large Flash Address Bit A16 |
| MOST Graphics | A0 | logic 1 | MOST Graphics Address Bit A0 |
| **Pin $\overline{\text{PCI\_CBE\_0}}$ Ball W10** | | | |
| PCI | PCI_CBE_0 | logic 1 | PCI Command Byte Enable 0 |
| LFLASH | A17 | logic 1 | Large Flash Address Bit A17 |
| MOST Graphics | A1 | logic 1 | MOST Graphics Address Bit A1 |
| **Pin $\overline{\text{PCI\_CBE\_1}}$ Ball Y08** | | | |
| PCI | PCI_CBE_1 | logic 1 | PCI Command Byte Enable 1 |
| LFLASH | A18 | logic 1 | Large Flash Address Bit A18 |
| MOST Graphics | A2 | logic 1 | MOST Graphics Address Bit A2 |
| **Pin $\overline{\text{PCI\_CBE\_2}}$ Ball W06** | | | |
| PCI | PCI_CBE_2 | logic 1 | PCI Command Byte Enable 2 |
| LFLASH | A19 | logic 1 | Large Flash Address Bit A19 |
| MOST Graphics | A3 | logic 1 | MOST Graphics Address Bit A3 |
| **Pin $\overline{\text{PCI\_CBE\_3}}$ Ball Y02** | | | |
| PCI | PCI_CBE_3 | logic 1 | PCI Command Byte Enable 3 |
| LFLASH | A20 | logic 1 | Large Flash Address Bit A20 |
| MOST Graphics | A4 | logic 1 | MOST Graphics Address Bit A4 |
| **Pin $\overline{\text{PCI\_TRDY}}$ Ball W05** | | | |
| PCI | PCI_TRDY | logic 1 | PCI_TRDY<br>PCI Target Ready |
| LFLASH | A21 | logic 1 | Large Flash Address Bit A21 |
| MOST Graphics | A5 | logic 1 | MOST Graphics Address Bit A5 |
| **Pin $\overline{\text{PCI\_IRDY}}$ Ball Y06** | | | |
| PCI | PCI_IRDY | logic 1 | PCI Initiator (HOST) Ready |
| LFLASH | A22 | logic 1 | Large Flash Address Bit A22 |
| MOST Graphics | A6 | logic 1 | MOST Graphics Address Bit A6 |

**Table 2-6. PCI Dedicated Signals (continued)**

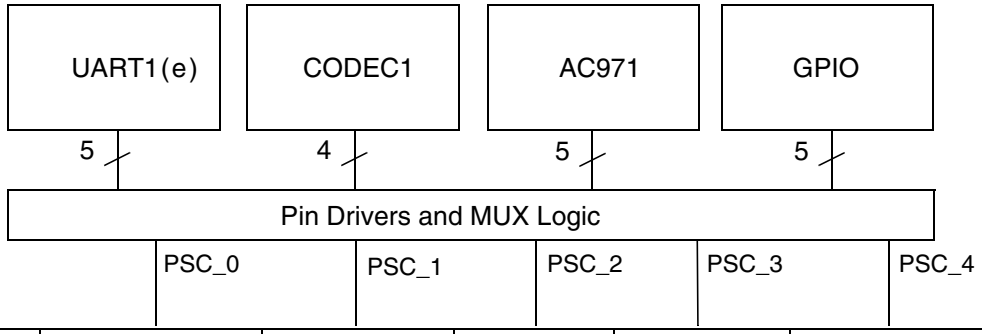
| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PCI_STOP Ball V06** | | | |
| PCI | PCI_STOP | logic 1 | PCI Transition Stop |
| LFLASH | A23 | logic 1 | Large Flash Address Bit A23 |
| MOST Graphics | A7 | logic 1 | MOST Graphics Address Bit A7 |
| **Pin PCI_DEVSEL Ball W07** | | | |
| PCI | PCI_DEVSEL | logic 1 | PCI Device Select |
| LFLASH | A24 | logic 1 | Large Flash Address Bit A24 |
| MOST Graphics | A8 | logic 1 | MOST Graphics Address Bit A8 |
| **Pin PCI_FRAME Ball V05** | | | |
| PCI | PCI_FRAME | logic 1 | PCI Frame Start |
| LFLASH | A25 | logic 1 | Large Flash Address Bit A25 |
| MOST Graphics | A9 | logic 1 | MOST Graphics Address Bit A9 |
| **Pin PCI_SERR Ball W08** | | | |
| PCI | PCI_SERR | logic 1 | PCI System Error (open drain) |
| MOST Graphics | A10 | logic 1 | MOST Graphics Address Bit A10 |
| **Pin PCI_PERR Ball Y07** | | | |
| PCI | PCI_SERR | logic 1 | PCI Parity Error |
| MOST Graphics | A11 | logic 1 | MOST Graphics Address Bit A11 |
| **Pin PCI_IDSEL Ball U02** | | | |
| PCI | PCI_IDSEL | logic 1 | PCI Initial Device Select |
| MOST Graphics | A12 | logic 1 | MOST Graphics Address Bit A12 |
| **Pin PCI_REQ Ball U01** | | | |
| PCI | PCI_REQ | logic 1 | PCI Bus Request |
| MOST Graphics | A13 | logic 1 | MOST Graphics Address Bit A13 |
| **Pin PCI_GNT Ball R04** | | | |
| PCI | PCI_GNT | logic 1 | PCI Bus Grant |
| MOST Graphics | A14 | logic 1 | MOST Graphics Address Bit A14 |
| **Pin PCI_CLOCK Ball T01** | | | |
| PCI | PCI_CLOCK | clk | PCI Clock |
| **Pin PCI_RESET Ball R02** | | | |
| PCI | PCI_RESET | logic 0 | PCI Reset Output (open drain) |
| MOST Graphics | A15 | logic 0 | MOST Graphics Address Bit A15 |

**Table 2-7. ATA Dedicated Signals**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin ATA_DRQ Ball V17** | | | |
| ATA | ATA_DRQ | logic 0 | ATA DMA Request |
| MOST Graphics | A16 | logic 0 | MOST Graphics Address Bit A16 |
| **Pin $\overline{\text{ATA\_DACK}}$ Ball Y18** | | | |
| ATA | ATA_DACK | logic 1 | ATA DMA Request |
| MOST Graphics | A17 | logic 1 | MOST Graphics Address Bit A17 |
| RESET Config. | | | bit 0 - ppc_pll_cfg_4 |
| **Pin $\overline{\text{ATA\_IOR}}$ Ball Y17** | | | |
| ATA | ATA_IOR | logic 1 | ATA read - 0, no read - 1 |
| MOST Graphics | A18 | logic 1 | MOST Graphics Address Bit A18 |
| RESET Config. | RST_CFG1 | | bit 1- ppc_pll_cfg_3 |
| **Pin $\overline{\text{ATA\_IOW}}$ Ball W17** | | | |
| ATA | ATA_IOW | logic 1 | ATA write - 0, no write - 1 |
| MOST Graphics | A19 | logic 1 | MOST Graphics Address Bit A19 |
| RESET Config. | RST_CFG2 | | bit 2 - ppc_pll_cfg_2 |
| **Pin ATA_IOCHDRY Ball W18** | | | |
| ATA | ATA_IOCHDRY | logic 1 | ATA negated to extend transfer |
| MOST Graphics | A20 | logic 1 | MOST Graphics Address Bit A20 |
| **Pin ATA_INTRQ Ball Y19** | | | |
| ATA | ATA_INTRQ | logic 1 | ATA Interrupt Request |
| MOST Graphics | A21 | logic 1 | MOST Graphics Address Bit A21 |
| **Pin ATA_ISOLATION Ball Y16** | | | |
| ATA | ATA_ISOLATION | logic 1 | ATA Levelshifter control signal |
| MOST Graphics | A22 | logic 1 | MOST Graphics Address Bit A22 |

**Table 2-8. LocalPlus Dedicated Signals**

| PIN / BALL NUMBER | Function | Reset Value | Description |
|---|---|---|---|
| **Pin $\overline{\text{LP\_RW}}$ Ball W16** | | | |
| LocalPlus | Read/Write | logic 1 | LocalPlus Read/Write LIne |
| Reset Configuration | RST_CFG3 | logic 1 | Bit 3 - ppc_pll_cfg_1 |
| **Pin $\overline{\text{LP\_ALE}}$ Ball V14** | | | |
| LocalPlus | Address Latch Enable | logic 1 | LocalPlus Address Latch Enable for Multiplexed Transitions |
| MOST Graphics | A23 | logic 1 | MOST Graphics Address Bit A23 |
| Reset Configuration | RST_CFG4 | logic 1 | Bit 4 ppc_pll_cfg_0 |
| **Pin LP_ACK Ball U14** | | | |
| LocalPlus | LP Acknowledge | logic 1 | Acknowledge signal for LP peripherals. Acknowledge signal for Large Flash or MOST Graphics, if bursts are not enabled. |
| LFLASH | BRST | logic 1 | BURST indication for Large Flash, if bursts are enabled |
| MOST Graphics | BRST | logic 1 | BURST indication for MOST Graphics, if bursts are enabled |
| **Pin $\overline{\text{LP\_TS}}$ Ball Y13** | | | |
| LocalPlus | LP Transfer Start | logic 1 | LocalPlus Transfer Start |
| Reset Configuration 5 | RST_CFG5 | logic 1 | Bit 5 - xlb_clk_sel<br>bit = 0: XLB_CLK = $f_{system}$ / 4<br>bit = 1: XLB_CLK = $f_{system}$ / 8 |
| **Pin $\overline{\text{LP\_OE}}$ Ball D08** | | | |
| LocalPlus | LP Output Enable | logic 1 | LocalPlus Output Enable |




| Function | Port_conf [29:31] | PSC_0 | PSC_1 | PSC_2 | PSC_3 | PSC_4 |
|---|---|---|---|---|---|---|
| GPIO | 00X | GPIO | GPIO | GPIO | GPIO | GPIO_W/WAKE_UP |
| AC97_1 | 01X | AC97_1_SDATA_OUT | AC97_1_SDATA_IN | AC97_1_SYNC | AC97_1_BITCLK | AC97_1_RES |
| UART1 | 100 | UART1_TXD | UART1_RXD | UART1_RTS | UART2_CTS | GPIO_W/WAKE_UP |
| UART1e | 101 | UART1e_TXD | UART1e_RXD | UART1e_RTS | UART1e_CTS | UART1e_DCD |
| CODEC1 | 110 | CODEC1_TXD | CODEC1_RXD | GPIO | CODEC1_CLK | CODEC1_FRAME |
| CODEC1 w/ MCLK | 111 | CODEC1_w/ MCLK_TXD | CODEC1_w/ MCLK_RXD | CODEC1_w/ MCLK_MCLK | CODEC1_w/ MCLK_CLK | CODEC1_w/ MCLK_FRAME |

**Notes:**

1. CODEC usage leaves pin 3 open for simple GPIO.
2. If port otherwise unused, all five pins are available as GPIO.
3. CODEC plus additional GPIO from elsewhere can implement Soft Modem or RS-232 functionality.
4. AC'97 usage is limited to PSC1 and PSC2.

**Figure 2-4. PSC1 Port Map—5 Pins**

**Table 2-9. PSC1 Pin Functions**

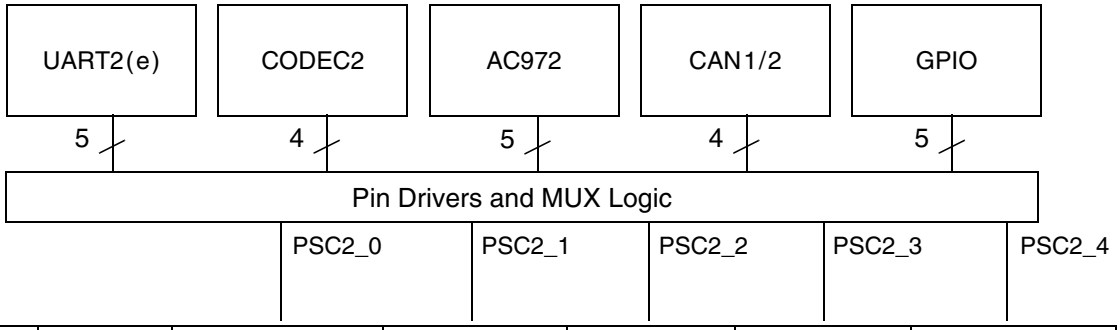
| Pin Name | Dir. | GPIO | AC97_1 | UART1 | UART1e | CODEC1 | CODEC1 w/ MCLK |
|---|---|---|---|---|---|---|---|
| PSC1_0 | I/O | GPIO | AC97_1_SDATA_ OUT | UART1_TXD | UART1e_TXD | CODEC1_ TXD | CODEC1_w/ MCLK_TXD |
| PSC1_1 | I/O | GPIO | AC97_1_SDATA_IN | UART1_RXD | UART1e_RXD | CODEC1_ RXD | CODEC1_w/ MCLK_RXD |
| PSC1_2 | I/O | GPIO | AC97_1_SYNC | UART1_RTS | UART1e_RTS | GPIO | CODEC1_w/ MCLK_MCLK |
| PSC1_3 | I/O | GPIO | AC97_1_BITCLK | UART1_CTS | UART1e_CTS | CODEC1_CLK | CODEC1_w/ MCLK_CLK |
| PSC1_4 | I/O | GPIO_W/ WAKE_ UP | AC97_1_RES | GPIO_W/ WAKE_UP | UART1e_DCD | CODEC1_ FRAME | CODEC1_w/ MCLK_FRAME |

**Table 2-10. PSC1 Functions by Pin**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PSC1_0 Ball B11** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| AC97_1 | | hi - z | AC97_1_SDATA_OUT<br>AC97 Serial Data Out |
| UART1 | | hi - z | UART1_TXD<br>Transmit Data |
| UART1e | | hi - z | UART1e_TXD<br>Transmit Data |
| CODEC1 | | hi - z | CODEC1_TXD<br>Transmit Data |
| CODEC1_w/MCLK | | hi - z | CODEC1_w/MCLK_TXD<br>Transmit Data |
| **Pin PSC1_1 Ball A11** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| AC97_1 | | hi - z | AC97_1_SDATA_IN<br>AC97 Serial Data In |
| UART1 | | hi - z | UART1_RXD<br>Receive Data |
| UART1e | | hi - z | UART1e_RXD<br>Receive Data |
| CODEC1 | | hi - z | CODEC1_RXD<br>Receive Data |
| CODEC1_w/MCLK | | hi - z | CODEC1_w/MCLK_RXD<br>Receive Data |
| **Pin PSC1_2 Ball C10** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| AC97_1 | | hi - z | AC97_1_SYNC<br>AC97 Frame Sync |
| UART1 | | hi - z | UART1_RTS<br>Ready To Send |
| UART1e | | hi - z | UART1e_RTS<br>Ready To Send |
| CODEC1 | | hi - z | GPIO<br>Simple General Purpose I/O |
| CODEC1_w/MCLK | | hi - z | CODEC1_w/MCLK _MCLK |

**Table 2-10. PSC1 Functions by Pin (continued)**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PSC1_3 Ball B10** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| AC97_1 | | hi - z | AC97_1_BITCLK<br>AC97 Bit Clock |
| UART1 | | hi - z | UART1_CTS<br>UART Clear To Send |
| UART1e | | hi - z | UART1e_CTS<br>UARTe Clear To Send |
| CODEC1 | | hi - z | CODEC1_CLK<br>CODEC Bit Clock |
| CODEC1_w/MCLK | | hi - z | CODEC1_w/MCLK_CLK<br>CODEC Bit Clock |
| **Pin PSC1_4 Ball A10** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O with WAKE UP |
| AC97_1 | | hi - z | AC97_1_RES<br>AC97 Reset |
| UART1 | | hi - z | GPIO<br>Simple General Purpose I/O with WAKE UP |
| UART1e | | hi - z | UART1e_DCD<br>UARTe Carrier Detect |
| CODEC1 | | hi - z | CODEC1_FRAME<br>CODEC Frame Sync |
| CODEC1_w/MCLK | | hi - z | CODEC1_w/MCLK_FRAME<br>CODEC Frame Sync |




| Function | Port_conf [25:27] | PSC_0 | PSC_1 | PSC_2 | PSC_3 | PSC_4 |
|---|---|---|---|---|---|---|
| GPIO | 000 | GPIO | GPIO | GPIO | GPIO | GPIO_W/WAKE_UP |
| CAN1/2 | 001 | CAN1_TX | CAN1_RX | CAN2_TX | CAN2_RX | GPIO_W/WAKE_UP |
| AC97_2 | 01X | AC97_2_SDATA_OUT | AC97_2_SDATA_IN | AC97_2_SYNC | AC97_2_BITCLK | AC97_2_RES |
| UART2 | 100 | UART2_TXD | UART2_RXD | UART2_RTS | UART2_CTS | GPIO_W/WAKE_UP |
| UART2e | 101 | UART2e_TXD | UART2e_RXD | UART2e_RTS | UART2e_CTS | UART2e_DCD |
| CODEC2 | 110 | CODEC2_TXD | CODEC2_RXD | GPIO | CODEC2_CLK | CODEC2_FRAME |
| CODEC2 w/ MCLK | 111 | CODEC2_w/ MCLK_TXD | CODEC2_w/ MCLK_RXD | CODEC2_w/ MCLK_MCLK | CODEC2_w/ MCLK_CLK | CODEC2_w/ MCLK_FRAME |

**Notes:**

1. CODEC usage leaves pin 3 open for simple GPIO.
2. CAN usage leaves pin 5 open for WakeUp GPIO.
3. CODEC plus additional GPIO from elsewhere can implement Soft Modem or RS-232 functionality.
4. AC97 usage is limited to PSC1 or PSC2.
5. MSCAN ports 1 and 2 can be configured here or on timer/$I^2C$ ports. They cannot be split. (i.e., put CAN1 on PSC2 and CAN2 on the timer port).
6. CAN RX input supports WakeUp functionality.

**Figure 2-5. PSC2 Port Map—5 Pins**

**Table 2-11. PSC2 Pin Functions**

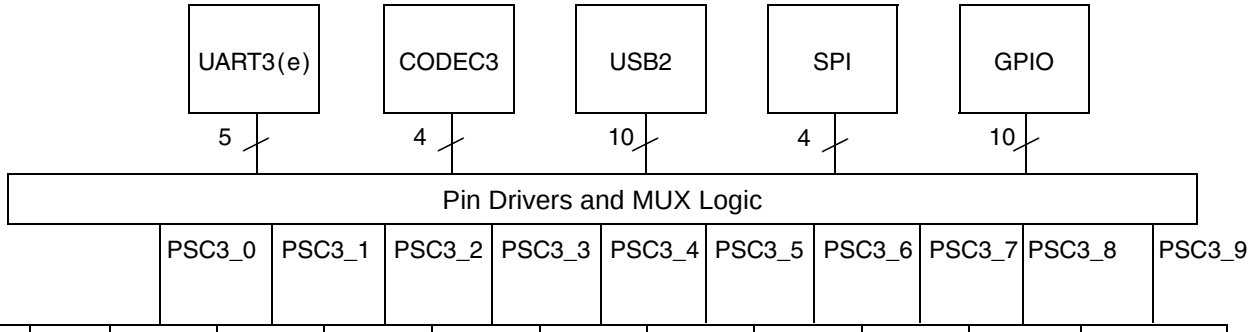
| Pin Name | Dir. | GPIO | CAN1/2 | AC97_2 | UART2 | UART2e | CODEC2 | CODEC2 w/ MCLK |
|---|---|---|---|---|---|---|---|---|
| PSC2_0 | I/O | GPIO | CAN1_TX | AC97_2_SDATA_OUT | UART2_TXD | UART2e_TXD | CODEC2_TXD | CODEC2_w/ MCLK_TXD |
| PSC2_1 | I/O | GPIO | CAN1_RX | AC97_2_SDATA_IN | UART2_RXD | UART2e_RXD | CODEC2_RXD | CODEC2_w/ MCLK_RXD |
| PSC2_2 | I/O | GPIO | CAN2_TX | AC97_2_SYNC | UART2_RTS | UART2e_RTS | GPIO | CODEC2_w/ MCLK_MCLK |
| PSC2_3 | I/O | GPIO | CAN2_RX | AC97_2_BITCLK | UART2_CTS | UART2e_CTS | CODEC2_CLK | CODEC2_w/ MCLK_CLK |
| PSC2_4 | I/O | GPIO_w/ WAKE_UP | GPIO_w/ WAKE_UP | AC97_2_RES | GPIO_w/ WAKE_UP | UART2e_DCD | CODEC2_FRAME | CODEC2_w/ MCLK_FRAME |

**Table 2-12. PSC2 Functions by Pin**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PSC2_0 Ball C09** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN1, CAN2 | | hi - z | CAN1_TX<br>CAN Transmit |
| AC97_2 | | hi - z | AC97_2_SDATA_OUT<br>AC97 Serial Data Out |
| UART2 | | hi - z | UART2_TXD<br>Transmit Data |
| UART2e | | hi - z | UART2e_TXD<br>Transmit Data |
| CODEC2 | | hi - z | CODEC2_TXD<br>Transmit Data |
| CODEC2_w/MCLK | | hi - z | CODEC2_w/MCLK_TXD<br>Transmit Data |
| **Pin PSC2_1 Ball B09** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN_1, CAN_2 | | hi - z | CAN1_RX<br>CAN Receive |
| AC97_2 | | hi - z | AC97_2_SDATA_IN<br>AC97 Serial Data In |
| UART2 | | hi - z | UART2_RXD<br>Receive Data |
| UART2e | | hi - z | UART2e_RXD<br>Receive Data |
| CODEC2 | | hi - z | CODEC2_RXD<br>Receive Data |

**Table 2-12. PSC2 Functions by Pin (continued)**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PSC2_2 Ball A09** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN1, CAN2 | | hi - z | CAN2_TX<br>CAN Transmit |
| AC97_2 | | hi - z | AC97_2_SYNC<br>AC97 Frame Sync |
| UART2 | | hi - z | UART2_RTS<br>Ready To Send |
| UART2e | | hi - z | UART2e_RTS<br>Ready To Send |
| CODEC2 | | hi - z | GPIO<br>Simple General Purpose I/O |
| **Pin PSC2_3 Ball B08** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN1, CAN2 | | hi - z | CAN2_RX<br>CAN Receive Data |
| AC97_2 | | hi - z | AC97_2_BITCLK<br>AC97 Bit Clock |
| UART2 | | hi - z | UART2_CTS<br>UART Clear To Send |
| UART2e | | hi - z | UART2e_CTS<br>UARTe Clear To Send |
| CODEC2 | | hi - z | CODEC2_CLK<br>CODEC Bit Clock |
| **Pin PSC2_4 Ball A08** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O with WAKE UP |
| CAN1, CAN2 | | hi - z | GPIO<br>Simple General Purpose I/O with WAKE UP |
| AC97_2 | | hi - z | AC97_2_RES<br>AC97 Reset |
| UART2 | | hi - z | GPIO<br>Simple General Purpose I/O with WAKE UP |
| UART2e | | hi - z | UART2e_DCD<br>UARTe Carrier Detect |
| CODEC2 | | hi - z | CODEC2_FRAME<br>CODEC Frame |




| Function | Port_ conf [20:23] | PSC3_0 | PSC3_1 | PSC3_2 | PSC3_3 | PSC3_4 | PSC3_5 | PSC3_6 | PSC3_7 | PSC3_8 | PSC3_9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GPIO | 0000 | GPIO | GPIO | GPIO | GPIO | LP_CS_6_ GPIO/ INTERRUPT | LP_CS_7_ GPIO/ INTERRUPT | GPIO | GPIO | GPIO/ INTERRUPT | GPIO_W/ WAKE-UP |
| USB2 | 0001 | USB2_OE | USB2_TXN | USB2_TXP | USB2_RXD | USB2_RXP | USB2_RXN | USB2_ PRTPWR | USB2_ SPEED | USB2_ SUSPEND | USB2_OVRCNT |
| UART3 | 0100 | UART3_ TXD | UART3_ RXD | UART3_ RTS | UART3_ CTS | LP_CS_6 | LP_CS_7 | GPIO | GPIO | GPIO/ INTERRUPT | GPIO_W/ WAKE_UP |
| UART3e | 0101 | UART3e_ TXD | UART3e_ RXD | UART3e_ RTS | UART3e_ CTS | UART3e_ DCD | LP_CS_7 | GPIO | GPIO | GPIO/ INTERRUPT | GPIO_W/ WAKE_UP |
| CODEC3 | 0110 | CODEC3_ TXD | CODEC3_ RXD | CODEC3_ CLK | CODEC3_ FRAME | LP_CS_6 | LP_CS_7 | GPIO | GPIO | GPIO/ INTERRUPT | GPIO_W/ WAKE_UP |
| CODEC3 w/ MCLK | 0111 | CODEC3_ w/ MCLK_TXD | CODEC3_ w/ MCLK_RXD | CODEC3_ w/MCLK_ CLK | CODEC3_w /MCLK_ FRAME | LP_CS_6 | LP_CS_7 | CODEC3_w /MCLK_ MCLK | GPIO | GPIO/ INTERRUPT | GPIO_W/ WAKE-UP |
| SPI | 100X | GPIO | GPIO | GPIO | GPIO | LP_CS_6 | LP_CS_7 | SPI_MOSI | SPI_MISO | SPI_SS | SPI_CLK |
| UART3 / SPI | 1100 | UART3_ TXD | UART3_ RXD | UART3_ RTS | UART3_ CTS | LP_CS_6 | LP_CS_7 | SPI_MOSI | SPI_MISO | SPI_SS | SPI_CLK |
| UART3e / SPI | 1101 | UART3e_ TXD | UART3e_ RXD | UART3e_ RTS | UART3e_ CTS | UART3e_ DCD | LP_CS_7 | SPI_MOSI | SPI_MISO | SPI_SS | SPI_CLK |
| CODEC3 / SPI | 111X | CODEC3_ TXD | CODEC3_ RXD | CODEC3_ CLK | CODEC3_ FRAME | LP_CS_6 | LP_CS_7 | SPI_MOSI | SPI_MISO | SPI_SS | SPI_CLK |

**Notes**:
1. If Soft Modem or RS-232 functionality is desired, use UARTe/CODEC function and use available GPIO from this or any other port.
2. Second USB port (USB2) can be configured on PSC3 or on the Ethernet port, but not both locations.
3. PSC3_4 can be configured to be LP_CS6 or an interrupt GPIO, except when PS3 is in USB2 or UART3e modes In these modes, CS6 is not available.
4. PSC3_5 can be configured to be LP_CS7 or an interrupt GPIO, except when PS3 is in USB2 mode. In this mode, LP_CS7 is not available.

**Figure 2-6. PSC3 Port Map—10 Pins**

**Table 2-13. PSC3 Pin Functions**

| Pin Name | Dir. | GPIO | USB2 | UART3 | UART3e | CODEC3 |
|---|---|---|---|---|---|---|
| PSC3_0 | I/O (O) | GPIO | USB2_OE | UART3_TXD | UART3e_TXD | CODEC3_TXD |
| PSC3_1 | I/O(I) | GPIO | USB2_TXN | UART3_RXD | UART3e_RXD | CODEC3_RXD |
| PSC3_2 | I/O(I) | GPIO | USB2_TXP | UART3_RTS | UART3e_RTS | CODEC3_CLK |
| PSC3_3 | I/O(I) | GPIO | USB2_RXD | UART3_CTS | UART3e_CTS | CODEC3_FRAME |
| PSC3_4 | I/O(I) | LP_CS_6_ GPIO/INTERRUPT | USB2_RXP | LP_CS_6 | UART3e_DCD | LP_CS_6 |
| PSC3_5 | I/O | LP_CS_7_ GPIO/INTERRUPT | USB2_RXN | LP_CS_7 | LP_CS_7 | LP_CS_7 |
| PSC3_6 | I/O | GPIO | USB2_PRTPWR | GPIO | GPIO | GPIO |
| PSC3_7 | I/O | GPIO | USB2_SPEED | GPIO | GPIO | GPIO |
| PSC3_8 | I/O | GPIO_ INTERRUPT_8 | USB2_SUSPEND | GPIO_INTERRUPT | GPIO_INTERRUPT | GPIO_INTERRUPT |
| PSC3_9 | I/O | GPIO_W/WAKE-UP | USB2_OVRCNT | GPIO_W/WAKE_UP | GPIO_W/WAKE_UP | GPIO_W/WAKE_UP |

**Table 2-14. PSC3 Pin Functions**

| Pin Name | Dir. | CODEC3 w/ M | SPI | UART3 / SPI | UART3e / SPI | CODEC3 / SPI |
|---|---|---|---|---|---|---|
| PSC3_0 | I/O | CODEC3_w/MCLK_TXD | GPIO | UART3_TXD | UART3e_TXD | CODEC3_TXD |
| PSC3_1 | I/O | CODEC3_w/MCLK_RXD | GPIO | UART3_RXD | UART3e_RXD | CODEC3_RXD |
| PSC3_2 | I/O | CODEC3_w/MCLK_CLK | GPIO | UART3_RTS | UART3e_RTS | CODEC3_CLK |
| PSC3_3 | I/O | CODEC3_w/MCLK_FRAME | GPIO | UART3_CTS | UART3e_CTS | CODEC3_FRAME |
| PSC3_4 | I/O | LP_CS_6 | LP_CS_6 | LP_CS_6 | UART3e_DCD | LP_CS_6 |
| PSC3_5 | I/O | LP_CS_7 | LP_CS_7 | LP_CS_7 | LP_CS_7 | LP_CS_7 |
| PSC3_6 | I/O | CODEC3_w/MCLK_MCLK | SPI_MOSI | SPI_MOSI | SPI_MOSI | SPI_MOSI |
| PSC3_7 | I/O | GPIO | SPI_MISO | SPI_MISO | SPI_MISO | SPI_MISO |
| PSC3_8 | I/O | GPIO_INTERRUPT | SPI_SS | SPI_SS | SPI_SS | SPI_SS |
| PSC3_9 | I/O | GPIO_W/WAKE-UP | SPI_CLK | SPI_CLK | SPI_CLK | SPI_CLK |

**Table 2-15. PSC3 Functions by Pin (Sheet 1 of 7)**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PSC3_0 Ball C07** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| USB2 | | hi - z | USB2_OE<br>USB Output Enable |
| UART3 | | hi - z | UART3_TXD<br>Uart Transmit Data |
| UART3e | | hi - z | UART3e_TXD<br>Uart Transmit Data |
| CODEC3 | | hi - z | CODEC3_TXD<br>CODEC Transmit Data |
| CODEC3_w/MCLK | | hi - z | CODEC3_w/MCLK_TXD<br>CODEC Transmit Data |
| SPI | | hi - z | GPIO<br>Simple General Purpose I/O |
| UART3, SPI | | hi - z | UART3_TXD<br>Uart Transmit Data |
| UART3e,SPI | | hi - z | UART3e_TXD<br>Uart Transmit Data |
| CODEC3, SPI | | hi - z | CODEC3_TXD<br>CODEC Transmit Data |

**Table 2-15. PSC3 Functions by Pin (Sheet 2 of 7)**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PSC3_1 Ball B07** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| USB2 | | hi - z | USB2_TXN<br>USB Transmit Negative |
| UART3 | | hi - z | UART3_RXD<br>Uart Receive Data |
| UART3e | | hi - z | UART3e_RXD<br>Uart Receive Data |
| CODEC3 | | hi - z | CODEC3_RXD<br>CODEC Receive Data |
| CODEC3_w/MCLK | | hi - z | CODEC3_w/MCLK_RXD<br>CODEC Receive Data |
| SPI | | hi - z | GPIO<br>Simple General Purpose I/O |
| UART3, SPI | | hi - z | UART3_RXD<br>Uart Receive Data |
| UART3e,SPI | | hi - z | UART3e_RXD<br>Uart Receive Data |
| CODEC3, SPI | | hi - z | CODEC3_RXD<br>CODEC Receive Data |

**Table 2-15. PSC3 Functions by Pin (Sheet 3 of 7)**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PSC3_2 Ball A07** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| USB2 | | hi - z | USB2_TXP<br>USB Transmit Positive |
| UART3 | | hi - z | UART3_RTS<br>Uart Ready To Send |
| UART3e | | hi - z | UART3e_RTS<br>Uart Ready To Send |
| CODEC3 | | hi - z | CODEC3_CLK<br>CODEC Bit Clock |
| CODEC3_w/MCLK | | hi - z | CODEC3_w/MCLK_CLK<br>CODEC Bit Clock |
| SPI | | hi - z | GPIO<br>Simple General Purpose I/O |
| UART3, SPI | | hi - z | UART3_RTS<br>Uart Ready to Send |
| UART3e, SPI | | hi - z | UART3_RTS<br>Uart Ready To Send |
| CODEC3, SPI | | hi - z | CODEC3_CLK<br>CODEC Clock |

**Table 2-15. PSC3 Functions by Pin (Sheet 4 of 7)**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PSC3_3 Ball C06** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| USB2 | | hi - z | USB2_RXD<br>USB Receive Data |
| UART3 | | hi - z | UART3_CTS<br>Uart Clear To Send |
| UART3e | | hi - z | UART3e_CTS<br>Uart Clear To Send |
| CODEC3 | | hi - z | CODEC3_FRAME<br>CODEC Frame Sync |
| CODEC3_w/MCLK | | hi - z | CODEC3_w/MCLK_FRAME<br>CODEC Frame Sync |
| SPI | | hi - z | GPIO<br>Simple General Purpose I/O |
| UART3, SPI | | hi - z | UART3_CTS<br>Uart Clear to Send |
| UART3e, SPI | | hi - z | UART3e_CTS<br>Uart Clear To Send |
| CODEC3, SPI | | hi - z | CODEC3_FRAME<br>CODEC Frame Sync |
| **Pin PSC3_4 Ball B06** | | | |
| GPIO | | hi - z | $\overline{\text{LP_CS_6}}$_GPIO_INTERRUPT |
| USB2 | | hi - z | USB2_RXP<br>USB Receive Positive |
| UART3 | | hi - z | $\overline{\text{LP_CS_6}}$_GPIO_INTERRUPT |
| UART3e | | hi - z | UART3e_DCD<br>UART3e Carrier Detect |
| CODEC3 | | hi - z | LP_CS_6 |
| CODEC3_w/MCLK | | hi - z | LP_CS_6 |
| SPI | | hi - z | LP_CS_6 |
| UART3, SPI | | hi - z | LP_CS_6 |
| UART3e,SPI | | hi - z | UART3e_DCD<br>UART3e Carrier Detect |
| CODEC3, SPI | | hi - z | LP_CS_6 |

**Table 2-15. PSC3 Functions by Pin (Sheet 5 of 7)**

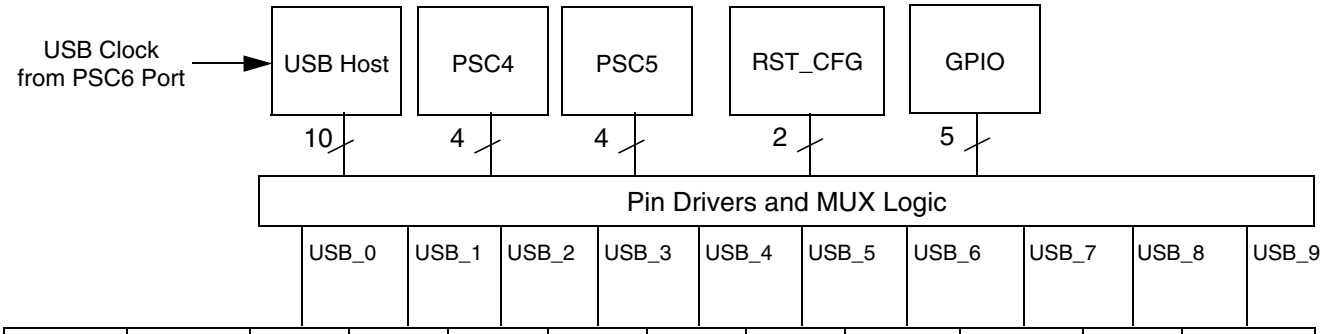
| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PSC3_5 Ball A06** | | | |
| GPIO | | hi - z | LP_CS_7_GPIO_INTERRUPT |
| USB2 | | hi - z | USB2_RXN<br>USB Receive Positive |
| UART3 | | hi - z | LP_CS_7 |
| UART3e | | hi - z | LP_CS_7 |
| CODEC3 | | hi - z | LP_CS_7 |
| CODEC3_w/MCLK | | hi - z | CODEC3_w/MCLK_MCLK<br>CODEC Clock |
| SPI | | hi - z | LP_CS_7 |
| UART3, SPI | | hi - z | LP_CS_7 |
| UART3e,SPI | | hi - z | LP_CS_7 |
| CODEC3, SPI | | hi - z | LP_CS_7 |
| **Pin PSC3_6 Ball C05** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| USB2 | | hi - z | USB2_PRTPWR<br>USB Port Power |
| UART3 | | hi - z | GPIO<br>Simple General Purpose I/O |
| UART3e | | hi - z | GPIO_<br>Simple General Purpose I/O |
| CODEC3 | | hi - z | GPIO<br>Simple General Purpose I/O |
| CODEC3_w/MCLK | | hi - z | LP_CS_7 |
| SPI | | hi - z | SPI_MOSI<br>SPI_Master Out Slave In |
| UART3, SPI | | hi - z | SPI_MOSI<br>SPI_Master Out Slave In |
| UART3e, SPI | | hi - z | SPI_MOSI<br>SPI_Master Out Slave In |
| CODEC3, SPI | | hi - z | SPI_MOSI<br>SPI_Master Out Slave In |

**Table 2-15. PSC3 Functions by Pin (Sheet 6 of 7)**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PSC3_7 Ball B05** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| USB2 | | hi - z | USB2_SPEED<br>USB Speed |
| UART3 | | hi - z | GPIO<br>Simple General Purpose I/O |
| UART3e | | hi - z | GPIO<br>Simple General Purpose I/O |
| CODEC3 | | hi - z | GPIO<br>Simple General Purpose I/O |
| CODEC3_w/MCLK | | hi - z | GPIO<br>Simple General Purpose I/O |
| SPI | | hi - z | SPI_MISO<br>SPI Master In Slave Out |
| UART3, SPI | | hi - z | SPI_MISO<br>SPI Master In Slave Out |
| UART3e, SPI | | hi - z | SPI_MISO<br>SPI Master In Slave Out |
| CODEC3, SPI | | hi - z | SPI_MISO<br>SPI Master In Slave Out |
| **Pin PSC3_8 Ball A05** | | | |
| GPIO | | hi - z | GPIO/INTERRUPT<br>Simple General Purpose I/O/INTERRUPT |
| USB_2 | | hi - z | USB2_SUSPEND<br>USB Suspend |
| UART3 | | hi - z | GPIO_INTERRUPT |
| UART3e | | hi - z | GPIO_INTERRUPT |
| CODEC3 | | hi - z | GPIO_INTERRUPT |
| CODEC3_w/MCLK | | hi - z | GPIO_INTERRUPT |
| SPI | | hi - z | SPI_SS<br>SPI Slave Select |
| UART_3, SPI | | hi - z | SPI_SS<br>SPI Slave Select |
| UART3e, SPI | | hi - z | SPI_SS<br>SPI Slave Select |
| CODEC3, SPI | | hi - z | SPI_SS<br>SPI Slave Select |

**Table 2-15. PSC3 Functions by Pin (Sheet 7 of 7)**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin PSC3_9 Ball C04** | | | |
| GPIO | | hi - z | GPIO_W/WAKE_UP<br>Simple General Purpose I/O with WAKE UP |
| USB2 | | hi - z | USB2_OVRCRNT<br>USB Over Current |
| UART3 | | hi - z | GPIO_W/WAKE_UP<br>Simple General Purpose I/O with WAKE UP |
| UART3e | | hi - z | GPIO_W/WAKE_UP<br>Simple General Purpose I/O with WAKE UP |
| CODEC3 | | hi - z | GPIO_W/WAKE_UP<br>Simple General Purpose I/O with WAKE UP |
| CODEC3_w/MCLK | | hi - z | GPIO_W/WAKE_UP<br>Simple General Purpose I/O with WAKE UP |
| SPI | | hi - z | SPI_CLK<br>SPI Clock |
| UART3, SPI | | hi - z | SPI_CLK<br>SPI Clock |
| UART3e, SPI | | hi - z | SPI_CLK<br>SPI Clock |
| CODEC3, SPI | | hi - z | SPI_CLK<br>SPI Clock |




| Function | Port_conf [18:19] | USB_0 | USB_1 | USB_2 | USB_3 | USB_4 | USB_5 | USB_6 | USB_7 | USB_8 | USB_9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RST_CFG | — | | RST_ CFG6 | RST_ CFG7 | | | | | | | |
| GPIO | 00 | GPIO | | | | | | GPIO | GPIO | GPIO | GPIO_ INTERRUPT |
| USB | 01 | USB1_ OE | USB1_ TXN | USB1_ TXP | USB1_ RXD | USB1_ RXP | USB1_ RXN | USB1_ PORTPWR | USB1_ SPEED | USB1_S USPEND | USB1_ OVERCNT |
| 2x UART4/5 | 10 | GPIO | UART4_ RTS | UART4_ TXD | UART4_ RXD | UART4_ CTS | UART5_ RXD | UART5_ TXD | UART5_ RTS | UART5_ CTS | INTERRUPT |

**Notes**:
1. If not used for USB, this port is available as a GPIO resource.
2. USB clock source can be generated internally or sourced from USB_CLK input.
3. Pins 3–5 are not mapped to any function other than USB.
4. RST_config bits are sampled only during Reset.
5. PSC4/5 can be used here or on the Ethernet port, but not in both places.

**Figure 2-7. USB Port Map—10 Pins**

**Table 2-16. USB Pin Functions**

| Pin Name | Dir. | Reset Configuration | GPIO | USB | 2x UART4/5 |
|---|---|---|---|---|---|
| USB_0 | I/O | | GPIO | USB1_OE | GPIO |
| USB_1 | I/O | RST_CFG6 | | USB1_TXN | UART4_RTS |
| USB_2 | I/O | RST_CFG7 | | USB1_TXP | UART4_TXD |
| USB_3 | I | | | USB1_RXD | UART4_RXD |
| USB_4 | I | | | USB1_RXP | UART4_CTS |
| USB_5 | I | | | USB1_RXN | UART5_RXD |
| USB_6 | I/O | | GPIO | USB1_PORTPWR | UART5_TXD |
| USB_7 | I/O | | GPIO | USB1_SPEED | UART5_RTS |
| USB_8 | I/O | | GPIO | USB1_SUSPEND | UART5_CTS |
| USB_9 | I/O | | INTERRUPT | USB1_OVERCNT | GPIO_INTERRUPT |

**Table 2-17. USB Pin Functions by Pin**

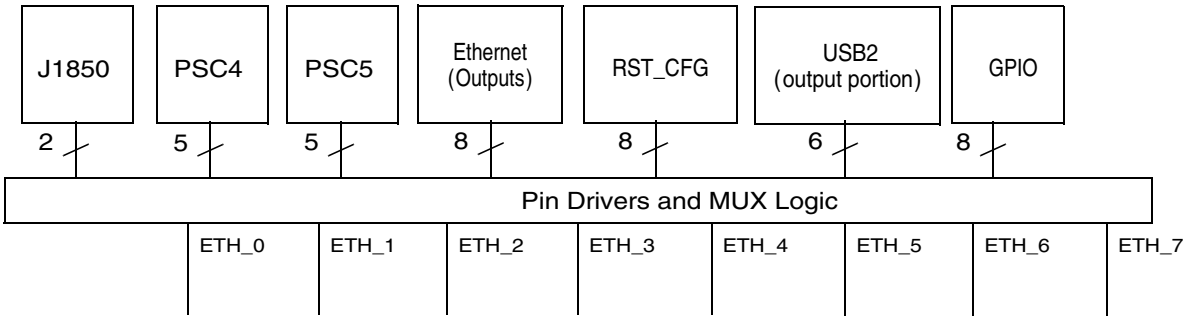
| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin USB_0 Ball H01** | | | |
| GPIO | | hi - z | GPIO |
| USB1 | | hi - z | USB1_OE |
| RESET Config. | | hi - z | — |
| UART4, UART5 | | hi - z | GPIO |
| **Pin USB_1 Ball H02** | | | |
| GPIO | | hi - z | — |
| USB1 | | hi - z | USB1_TXN<br>USB1 Transmit Negative |
| RESET Config. | | hi - z | RST_CFG6 - sys_pll_cfg_0<br>bit =0 : $f_{system}$ = 16x SYS_XTAL_IN<br>bit =1 : $f_{system}$ = 12x SYS_XTAL_IN |
| UART4, UART5 | | hi - z | UART4_RTS |
| **Pin USB_2 Ball H03** | | | |
| GPIO | | hi - z | — |
| USB1 | | hi - z | USB1_TXP<br>USB1 Transmit Positive |
| RESET Config. | | hi - z | RST_CFG7<br>(Pull bit low) |
| UART4, UART5 | | hi - z | UART4_TXD<br>Uart Transmit Data |
| **Pin USB_3 Ball G01** | | | |
| GPIO | | hi - z | — |
| USB1 | | hi - z | USB1_RXD<br>USB1 Receive Data |
| RESET Config. | | hi - z | — |
| UART4, UART5 | | hi - z | UART4_RXD<br>Uart Receive Data |
| **Pin USB_4 Ball G02** | | | |
| GPIO | | hi - z | — |
| USB1 | | hi - z | USB1_RXP<br>USB1 Receive Positive |
| RESET Config. | | hi - z | — |
| UART_, UART5 | | hi - z | UART4_CTS<br>Uart Clear To Send |

**Table 2-17. USB Pin Functions by Pin (continued)**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin USB_5 Ball G03** | | | |
| GPIO | | hi - z | — |
| USB1 | | hi - z | USB1_RXN<br>USB1 Receive Negative |
| RESET Config. | | hi - z | — |
| UART4, UART5 | | hi - z | UART5_RXD<br>Uart Receive Data |
| **Pin USB_6 Ball G04** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| USB1 | | hi - z | USB1_PRTPWR<br>USB Receive Negative |
| RESET Config. | | hi - z | — |
| UART4, UART5 | | hi - z | UART5_TXD<br>Uart Transmit Data |
| **Pin USB_7 Ball F01** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| USB1 | | hi - z | USB1_SPEED<br>USB Speed |
| RESET Config. | | hi - z | — |
| UART4, UART5 | | hi - z | UART5_RTS<br>Uart Ready To Send |
| **Pin USB_8 Ball F02** | | | |
| GPIO | | hi - z | GPIO<br>Simple General Purpose I/O |
| USB1 | | hi - z | USB1_SUSPEND<br>USB Suspend |
| RESET Config. | | hi - z | — |
| UART4, UART5 | | hi - z | UART5_CTS<br>Uart Clear To Send |

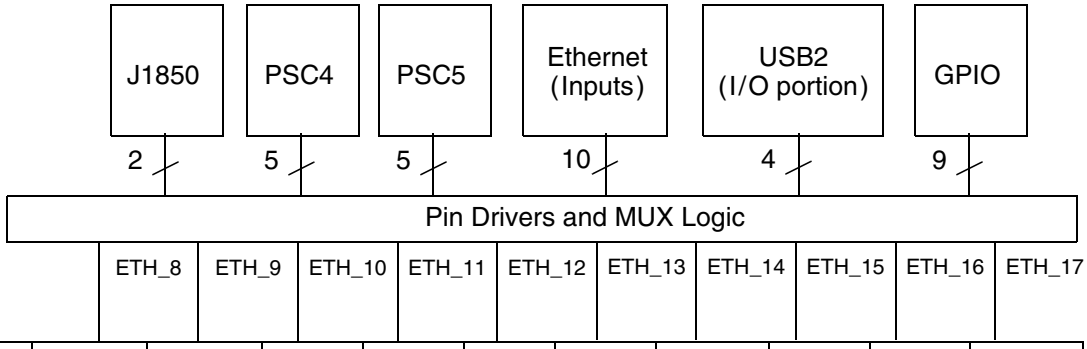
**Table 2-17. USB Pin Functions by Pin (continued)**

| Pin / Ball Number | Function | Reset Value | Description |
|---|---|---|---|
| **Pin USB_9 Ball F03** | | | |
| GPIO | | hi - z | GPIO/INTERRUPT<br>Simple General Purpose I/O/INTERRUPT |
| USB1 | | hi - z | USB1_OVRCRNT<br>USB1 Over Current |
| RESET Config. | | hi - z | — |
| UART4, UART5 | | hi - z | INTERRUPT |




| Function | Port_conf [12:15] | ETH_0 | ETH_1 | ETH_2 | ETH_3 | ETH_4 | ETH_5 | ETH_6 | ETH_7 |
|---|---|---|---|---|---|---|---|---|---|
| RST_CFG | — | RST_CFG8 | RST_CFG15 | RST_CFG10 | RST_CFG11 | RST_CFG12 | RST_CFG13 | RST_CFG14 | — |
| GPIO | 0000 | OUTPUT | OUTPUT | OUTPUT | OUTPUT | OUTPUT | OUTPUT | OUTPUT | OUTPUT |
| USB2 | 0001 | OUTPUT | OUTPUT | USB2_TXP | USB2_ PRTPWR | USB2_SPEED | USB2_ SUSPEND | USB2_OE | USB2_TXN |
| ETH7 | 0010 | ETH7_TXEN | ETH7_TXD_0 | OUTPUT | OUTPUT | OUTPUT | OUTPUT | OUTPUT | OUTPUT |
| ETH7 / USB2 | 0011 | ETH7_TXEN | ETH7_TXD_0 | USB2_TXP | USB2_ PRTPWR | USB2_SPEED | USB2_ SUSPEND | USB2_OE | USB2_TXN |
| ETH_18 no MD | 0100 | ETH18_TXEN | ETH18_TXD_0 | ETH18_TXD_1 | ETH18_TXD_2 | ETH18_TXD_3 | ETH18_ TXERR | OUTPUT | OUTPUT |
| ETH_18 w/ MD | 0101 | ETH18_w/MD_ TXEN | ETH18_w/ MD_TXD_0 | ETH18_w/ MD_TXD_1 | ETH18_w/ MD_TXD_2 | ETH18_w/MD_ TXD_3 | ETH18_w/MD_ TXERR | ETH18_w/MD_ MDC | ETH18_w/MD_ MDIO |
| ETH7 / UART4e/J1850 | 1000 | ETH7_TXEN | ETH7_TXD_0 | OUTPUT | UART4e_TXD | J1850_TX | UART4e_RTS | OUTPUT | OUTPUT |
| ETH7 /J1850 | 1001 | ETH7_TXEN | ETH7_TXD_0 | OUTPUT | OUTPUT | J1850_TX | OUTPUT | OUTPUT | OUTPUT |
| UART4/ 5e/J1850 | 1010 | OUTPUT | UART5e_TXD | UART5e_RTS | UART4_TXD | J1850_TX | UART4_RTS | OUTPUT | OUTPUT |
| UART5e/J1850 | 1011 | OUTPUT | UART5e__ TXD | UART5e_RTS | OUTPUT | J1850_TX | OUTPUT | OUTPUT | OUTPUT |
| J1850 | 1100 | OUTPUT | OUTPUT | OUTPUT | OUTPUT | J1850_TX | OUTPUT | OUTPUT | OUTPUT |

**Figure 2-8. Ethernet Output Port Map—8 Pins**




| Function | Port_ conf [12:15] | ETH_8 | ETH_9 | ETH_10 | ETH_11 | ETH_12 | ETH_13 | ETH_14 | ETH_15 | ETH_16 | ETH_17 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RST_CFG | | | | | | | | | | | |
| GPIO | 0000 | GPIO | GPIO | GPIO | GPIO | | GPIO/ INTERRUPT | GPIO/ INTERRUPT | GPIO/ INTERRUPT | GPIO/ INTERRUPT | GPIO_W/WAKE_UP |
| USB2 | 0001 | GPIO | GPIO | GPIO | GPIO | | USB2_RXD | USB2_RXP | USB2_RXN | USB2_ OVRCNT | GPIO_W/ WAKE_UP |
| ETH7 | 0010 | ETH7_CD | ETH7_RXCLK | ETH7_COL | ETH7_ TXCLK | ETH7_ RXD_0 | GPIO/ INTERRUPT | GPIO/ INTERRUPT | GPIO/ INTERRUPT | GPIO/ INTERRUPT | GPIO_W/ WAKE_UP |
| ETH7/USB2 | 0011 | ETH7_CD | ETH7_RXCLK | ETH7_COL | ETH7_ TXCLK | ETH7_RXD _0 | USB2_RXD | USB2_RXP | USB2_RXN | USB2_ OVRCNT | GPIO_W/ WAKE_UP |
| ETH_18 no MD | 0100 | ETH18_RXDV | ETH18_ RXCLK | ETH18_COL | ETH18_ TXCLK | ETH18_ RXD_0 | ETH18_ RXD_1 | ETH18_RXD_ 2 | ETH18_RXD _3 | ETH18_RXE RR | ETH18_CRS |
| ETH_18 w/ MD | 0101 | ETH18_w/MD_ RXDV | ETH18_w/MD_ RXCLK | ETH18_w/M D_COL | ETH18_TXD | ETH18_w/ MD_RXD_0 | ETH18_w/M D_RXD_1 | ETH18_w/MD _RXD_2 | ETH18_w/M D_RXD_3 | ETH18_w/M D_RXERR | ETH18_W/MD _CRS |
| ETH7 / UART4e/ J1850 | 1000 | ETH7_CD | ETH7_RXCLK | ETH7_COL | ETH7_ TXCLK | ETH7_RXD _0 | J1850_RX | UART4e_RXD | UART4e_ CTS | UART4_DCD | GPIO_W/ WAKE_UP |
| ETH7/J1850 | 1001 | ETH7_CD | ETH7_RXCLK | ETH7_COL | ETH7_ TXCLK | ETH7_RXD _0 | J1850_RX | GPIO/ INTERRUPT | GPIO/ INTERRUPT | GPIO/ INTERRUPT | GPIO_W/ WAKE_UP |
| UART4/5e/ J1850 | 1010 | UART5e_CD | UART5e_CTS | OUTPUT | OUTPUT | UART5e_ RXD | J1850_RX | UART4_RXD | UART4_CTS | UART4_CD | GPIO_W/ WAKE_UP |
| UART5e/ J1850 | 1011 | UART5e_DCD | UART5e_CTS | OUTPUT | OUTPUT | UART5e_ RXD | J1850_RX | GPIO/ INTERRUPT | GPIO/ INTERRUPT | GPIO/ INTERRUPT | GPIO_W/ WAKE_UP |
| J1850 | 1100 | GPIO | OUTPUT | OUTPUT | OUTPUT | | J1850_RX | GPIO/ INTERRUPT | GPIO/ INTERRUPT | GPIO/ INTERRUPT | GPIO_W/ WAKE_UP |

**Figure 2-9. Ethernet Input / Control Port Map—10 Pins**

**Table 2-18. Ethernet Pin Functions**

| Pin Name | Dir. | Reset Configuration | GPIO | USB2 | ETH7 | ETH7 / USB2 |
|---|---|---|---|---|---|---|
| ETH_0 | I/O | RST_CFG8 | OUTPUT | OUTPUT | ETH7_TXEN | ETH7_TXEN |
| ETH_1 | I/O | RST_CFG15 | OUTPUT | OUTPUT | ETH7_TXD_0 | ETH7_TXD_0 |
| ETH_2 | I/O | RST_CFG10 | OUTPUT | USB2_TXP | OUTPUT | USB2_TXP |
| ETH_3 | I/O | RST_CFG11 | OUTPUT | USB2_PRTPWR | OUTPUT | USB2_PRTPWR |
| ETH_4 | I/O | RST_CFG12 | OUTPUT | USB2_SPEED | OUTPUT | USB2_SPEED |
| ETH_5 | I/O | RST_CFG13 | OUTPUT | USB2_SUSPEND | OUTPUT | USB2_SUSPEND |
| ETH_6 | I/O | RST_CFG14 | OUTPUT | USB2_OE | OUTPUT | USB2_OE |
| ETH_7 | I/O | — | OUTPUT | USB2_TXN | OUTPUT | USB2_TXN |
| ETH_8 | I/O | — | GPIO | GPIO | ETH7__CD | ETH7__CD |
| ETH_9 | I/O | — | GPIO | GPIO | ETH7_RXCLK | ETH7_RXCLK |
| ETH_10 | I/O | — | GPIO | GPIO | ETH7_COL | ETH7_COL |
| ETH_11 | I/O | — | GPIO | GPIO | ETH7_TXCLK | ETH7_TXCLK |
| ETH_12 | I | — | — | — | ETH7_RXD_0 | ETH7_RXD_0 |
| ETH_13 | I/O | — | GPIO/INTERRUPT | USB2_RXD | GPIO/INTERRUPT | USB2_RXD |
| ETH_14 | I/O | — | GPIO/INTERRUPT | USB2_RXP | GPIO/INTERRUPT | USB2_RXP |
| ETH_15 | I/O | — | GPIO/INTERRUPT | USB2_RXN | GPIO/INTERRUPT | USB2_RXN |
| ETH_16 | I/O | — | GPIO/INTERRUPT | USB2_OVRCNT | GPIO/INTERRUPT | USB2_OVRCNT |
| ETH_17 | I/O | — | GPIO_W/WAKE-UP | GPIO_W/WAKE-UP | GPIO_W/WAKE-UP | GPIO_W/ WAKE-UP |

**Table 2-19. Ethernet Pin Functions**

| Pin name | Dir. | ETH_18 no MD | ETH_18 w/ MD | ETH7 / UART4e/ J1850 | ETH7/J1850 | 2UART4/5e/J 1850 | UART5e/J 1850 | J1850 |
|---|---|---|---|---|---|---|---|---|
| ETH_0 | I/O | ETH18_TXEN | ETH18_w/IMD _TXEN | ETH7_TXEN | ETH7_TXEN | OUTPUT | OUTPUT | OUTPUT |
| ETH_1 | I/O | ETH18_TXD_0 | ETH18_w/ MD_TXD_0 | ETH7_TXD_0 | ETH7_TXD_0 | UART5e__TXD | UART5e__TXD | OUTPUT |
| ETH_2 | I/O | ETH18_TXD_1 | ETH18_w/ MD_TXD_1 | OUTPUT | OUTPUT | UART5e__RTS | UART5e__RTS | OUTPUT |
| ETH_3 | I/O | ETH18_TXD_2 | ETH18_w/ MD_TXD_2 | UART4e_TXD | OUTPUT | P4_TXD | OUTPUT | OUTPUT |
| ETH_4 | I/O | ETH18_TXD_3 | ETH18_w/ MD_TXD_3 | J1850_TX | J1850_TX | J1850_TX | J1850_TX | J1850_TX |
| ETH_5 | I/O | ETH18_ TXERR | ETH18_w/ MD_TXERR | UART4e__ RTS | OUTPUT | UART4_RTS | OUTPUT | OUTPUT |
| ETH_6 | I/O | OUTPUT | ETH18_w/ MD_MDC | OUTPUT | OUTPUT | OUTPUT | OUTPUT | OUTPUT |
| ETH_7 | I/O | OUTPUT | ETH18_w/ MD_MDIO | OUTPUT | OUTPUT | OUTPUT | OUTPUT | OUTPUT |
| ETH_8 | I/O | ETH18_RXDV | ETH18_w/ MD_RXDV | ETH7__CD | ETH7__CD | UART5e__DCD | UART5e__DCD | GPIO |
| ETH_9 | I/O | ETH18_ RXCLK | ETH18_w/ MD_RXCLK | ETH7_RXCLK | ETH7_RXCLK | UART5e__CTS | UART5e__CTS | GPIO |
| ETH_10 | I/O | ETH18_COL | ETH18_w/ MD_COL | ETH7_COL | ETH7_COL | GPIO | GPIO | GPIO |
| ETH_11 | I/O | ETH18_ TXCLK | ETH18_w/ MD_TXCLK | ETH7_TXCLK | ETH7_TXCLK | GPIO | GPIO | GPIO |
| ETH_12 | I | ETH18_ RXD_0 | ETH18_w/ MD_RXD_0 | ETH7_RXD_O | ETH7_RXD_O | UART5e__RXD | UART5e__RXD | — |
| ETH_13 | I/O | ETH18_ RXD_1 | ETH18_w/ MD_RXD_1 | J1850_RX | J1850_RX | J1850_RX | J1850_RX | J1850_RX |
| ETH_14 | I/O | ETH18_ RXD_2 | ETH18_w/ MD_RXD_2 | UART4e__ RXD | GPIO/ INTERRUPT | UART4_RXD | GPIO/ INTERRUPT | GPIO/ INTERRUPT |
| ETH_15 | I/O | ETH18_ RXD_3 | ETH18_w/ MD_RXD_3 | UART4e__ CTS | GPIO/ INTERRUPT | UART4_CTS | GPIO/ INTERRUPT | GPIO/ INTERRUPT |
| ETH_16 | I/O | ETH18_ RXERR | ETH18_w/ MD_RXERR | UART4e__ DCD | GPIO/ INTERRUPT | UART4_CD | GPIO/ INTERRUPT | GPIO/ INTERRUPT |
| ETH_17 | I/O | ETH18_CRS | ETH18_w/ MD_CRS | GPIO_W/ WAKE-UP | GPIO_W/ WAKE-UP | GPIO_W/ WAKE-UP | GPIO_W/ WAKE-UP | GPIO_W/ WAKE-UP |

**Table 2-20. Ethernet Output Functions by Pin (Sheet 1 of 8)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin ETH_0 Ball K01** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output |
| USB2 | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire | hi - z | ETH_TX_EN<br>Ethernet Transmit Enable |
| ETH7 Wire / USB2 | hi - z | ETH_TX_EN<br>Ethernet Transmit Enable |
| ETH18 Wire w/o MD | hi - z | ETH_TX_EN<br>Ethernet Transmit Enable |
| ETH18 Wire w/ MD | hi - z | ETH_TX_EN<br>Ethernet Transmit Enable |
| ETH7 Wire, UART4e, J1850 | hi - z | ETH_TX_EN<br>Ethernet Transmit Enable |
| ETH7 Wire, J1850 | hi - z | ETH_TX_EN<br>Ethernet Transmit Enable |
| UART_4, UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| RESET Config. 8 | hi - z | bit 8 - most_graphics_sel<br>bit = 0: Most Graphics boot not enabled<br>bit = 1: Most Graphics boot enabled. |

**Table 2-20. Ethernet Output Functions by Pin (Sheet 2 of 8)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin ETH_1 Ball K02** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output |
| USB2 | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire | hi - z | ETH_TXD_0<br>Ethernet Transmit Data Output |
| ETH7 Wire / USB2 | hi - z | ETH_TXD_0<br>Ethernet Transmit Data Output |
| ETH18 Wire w/o MD | hi - z | ETH_TXD_0<br>Ethernet Transmit Data Output |
| ETH18 Wire w/ MD | hi - z | ETH_TXD_0<br>Ethernet Transmit Data Output |
| EHT7 Wire, UART4e, J1850 | hi - z | ETH_TXD_0<br>Ethernet Transmit Data Output |
| ETH7 Wire, J1850 | hi - z | ETH_TXD_0<br>Ethernet Transmit Data Output |
| UART_4, UART5e, J1850 | hi - z | UART5e_TXD<br>Uart Transmit Data |
| UART5e, J1850 | hi - z | UART5e_TXD<br>Uart Transmit Data |
| J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| RESET Config. | hi - z | bit 15 - large_flash_sel<br>bit = 0: Large Flash boot not enabled<br>bit = 1: Large Flash boot enabled.<br>See Note 3. |

**Table 2-20. Ethernet Output Functions by Pin (Sheet 3 of 8)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin ETH_2 Ball K03** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output |
| USB2 | hi - z | USB2_TXP<br>USB Transmit Positive |
| ETH7 Wire | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire / USB2 | hi - z | USB2_TXP<br>USB Transmit Positive |
| ETH18 Wire w/o MD | hi - z | ETH_TXD_1<br>Ethernet Transmit Data Output |
| ETH18 Wire w/ MD | hi - z | ETH_TXD_1<br>Ethernet Transmit Data Output |
| EHT7 Wire, UART4e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| UART_4, UART5e, J1850 | hi - z | UART5e_RTS<br>Uart Transmit Data |
| UART5e, J1850 | hi - z | UART5e_RTS<br>Uart Transmit Data |
| J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| RESET Config. | hi - z | bit 10 - ppc_msrip PPC Boot Address / Exception Table Loc.<br>bit = 0: 0000 0100 (hex)<br>bit = 1: fff0 0100 (hex) |

**Table 2-20. Ethernet Output Functions by Pin (Sheet 4 of 8)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin ETH_3 Ball J01** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output |
| USB2 | hi - z | USB2_PrtPWR<br>USB Port Power |
| ETH7 Wire | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire / USB2 | hi - z | USB2_PrtPWR<br>USB Port Power |
| ETH18 Wire w/o MD | hi - z | ETH_TXD_2<br>Ethernet Transmit Data Output |
| ETH18 Wire w/ MD | hi - z | ETH_TXD_2<br>Ethernet Transmit Data Output |
| EHT7 Wire, UART4e, J1850 | hi - z | UART_4_TXD<br>Uart Transmit Data |
| ETH7 Wire, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| UART_4, UART5e, J1850 | hi - z | UART_4_TXD<br>Uart Transmit Data |
| UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| RESET Config. | hi - z | bit 11 - boot_rom_wait<br>bit = 0: 4 IPbus clocks of waitstate*<br>bit = 1: 48 IPbus clocks of waitstate* |

**Table 2-20. Ethernet Output Functions by Pin (Sheet 5 of 8)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin ETH_4 Ball J02** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output |
| USB2 | hi - z | USB2_Speed<br>USB Speed |
| ETH7 Wire | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire / USB2 | hi - z | USB2_Speed<br>USB Speed |
| ETH18 Wire w/o MD | hi - z | ETH_TXD_3<br>Ethernet Transmit Data Output |
| ETH18 Wire w/ MD | hi - z | ETH_TXD_3<br>Ethernet Transmit Data Output |
| EHT7 Wire, UART4e, J1850 | hi - z | J1850_TX<br>J1850 Transmit Data |
| ETH7 Wire, J1850 | hi - z | J1850_TX<br>J1850 Transmit Data |
| UART_4, UART5e, J1850 | hi - z | J1850_TX<br>J1850 Transmit Data |
| UART5e, J1850 | hi - z | J1850_TX<br>J1850 Transmit Data |
| J1850 | hi - z | J1850_TX<br>J1850 Transmit Data |
| RESET Config. | hi - z | bit 12 - boot_rom_swap<br>bit = 0: no byte lane swap - same endian ROM image<br>bit = 1: byte lane swap - different endian ROM image |

**Table 2-20. Ethernet Output Functions by Pin (Sheet 6 of 8)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin ETH_5 Ball L03** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output |
| USB2 | hi - z | USB2_Suspend<br>USB Suspend |
| ETH7 Wire | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire / USB2 | hi - z | USB2_Suspend<br>USB Suspend |
| ETH18 Wire w/o MD | hi - z | ETH_TXERR<br>Ethernet Transmit Error Output |
| ETH18 Wire w/ MD | hi - z | ETH_TXERR<br>Ethernet Transmit Error Output |
| EHT7 Wire, UART4e, J1850 | hi - z | UART_4_RTS<br>Uart Ready To Send |
| ETH7 Wire, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| UART_4, UART5e, J1850 | hi - z | UART_4_RTS<br>Uart Ready To Send |
| UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| RESET Config. | hi - z | bit 13 - boot_rom_size For “non-muxed” boot ROMs<br>bit = 0: 8-bit boot ROM data bus / 24-bit boot ROM address<br>bit = 1: 16-bit boot ROM data bus / 16-bit boot ROM address<br>For muxed boot ROMs boot ROM addr is max 25 significant bits during address tenure.<br>bit = 0: 16-bit ROM data bus<br>bit = 1: 32-bit ROM data bus<br>For large flash boot case boot Flash addr is 25 bits.<br>bit = 0: 8-bit Flash data bus<br>bit = 1: 16-bit Flash data bus |

**Table 2-20. Ethernet Output Functions by Pin (Sheet 7 of 8)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin ETH_6 Ball N02** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output |
| USB2 | hi - z | USB2_OE<br>USB Output Enable |
| ETH7 Wire | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire / USB2 | hi - z | USB2__OE<br>USB Output Enable |
| ETH18 Wire w/o MD | hi - z | GPIO<br>Simple General Purpose Output |
| ETH18 Wire w/ MD | hi - z | ETH_MDC<br>Ethernet Transmit Error Output |
| EHT7 Wire, UART4e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| UART_4, UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| RESET Config. | hi - z | bit 14 - boot_rom_wait<br>bit = 0: non-muxed boot ROM bus, single tenure transfer.<br>bit = 1: muxed boot ROM bus, PPC like with address & data tenures,<br>Alibi & TS_b active.<br>Note 3. |

**Table 2-20. Ethernet Output Functions by Pin (Sheet 8 of 8)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin ETH_7 Ball N01** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output |
| USB2 | hi - z | USB2_TXN<br>USB Transmit Negative |
| ETH7 Wire | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire / USB2 | hi - z | USB2_TXN<br>USB Transmit Negative |
| ETH18 Wire w/o MD | hi - z | GPIO<br>Simple General Purpose Output |
| ETH18 Wire w/ MD | hi - z | ETH_MDIO<br>Ethernet Management Data I/O |
| EHT7 Wire, UART4e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| UART_4, UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| J1850 | hi - z | GPIO<br>Simple General Purpose Output |

**Notes:**

1. The external bus clock (pci_clk) will be 1/2 the frequency of the internal bus clock (ipb_clk) at powerup. Therefore, 4 IPbus wait states will translate to as little as 1 external wait state (i.e. peripheral must respond within 2 external clocks). The “slow” setting represents 48 IPbus clocks of wait, or 23 external clocks of wait External waits are minus-1 because Chip Select may assert on falling edge of external bus clock (dependant on internal timing).
2. For muxed boot ROM types, the width of ALE_b & TS_b will be 2 IPbus clocks (i.e. 1 external clock). This represents the wide ALE setting in the LocalPlus Controller (LPC). Care must be taken if these clock relationships are to be changed during the boot process. For the 1-to-1 internal-to-external clock setting (which must be programmed by software into the CDM), be sure to change the ALE width setting (in LPC) *after* adjusting the clock relationship. Any fetches to the boot device between these two settings will result in ALE and TS being 2 external clocks wide.
3. Only one boot mode can be enabled at a time. Large Flash and Most Graphics cannot be enabled at the same time. If neither Large Flash or Most Graphics is enabled, boot will occur from the normal LocalPlus mode, either muxed or nonmuxed (depending on the boot_rom_type configuration input).

**Table 2-21. Ethernet Input / Control Functions by Pin (Sheet 1 of 7)**

| PIN / BALL NUMBER | Reset Value | Description |
|---|---|---|
| **Pin ETH_8 Ball M03** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output |
| USB2 | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire | hi - z | ETH_CD<br>Ethernet Carrier Detect |
| ETH7 Wire / USB2 | hi - z | ETH_CD<br>Ethernet Carrier Detect |
| ETH18 Wire w/o MD | hi - z | ETH_RXDV<br>Ethernet Receive Data Valid |
| ETH18 Wire w/ MD | hi - z | ETH_RXDV<br>Ethernet Receive Data Valid |
| EHT7 Wire, UART4e, J1850 | hi - z | ETH_CD<br>Ethernet Carrier Detect |
| ETH7 Wire, J1850 | hi - z | ETH_CD<br>Ethernet Carrier Detect |
| UART_4, UART5e, J1850 | hi - z | UART5e_DCD<br>Uart Carrier Detect |
| UART5e, J1850 | hi - z | UART5e_DCD<br>Uart Carrier Detect |
| J1850 | hi - z | GPIO<br>Simple General Purpose Output |

**Table 2-21. Ethernet Input / Control Functions by Pin (Sheet 2 of 7)**

| PIN / BALL NUMBER | Reset Value | Description |
|---|---|---|
| **Pin ETH_9 Ball L01** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output |
| USB2 | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire | hi - z | ETH_RXCLK<br>Ethernet Receive Clock |
| ETH7 Wire / USB2 | hi - z | ETH_RXCLK<br>Ethernet Receive Clock |
| ETH18 Wire w/o MD | hi - z | ETH_RXCLK<br>Ethernet Receive Clock |
| ETH18 Wire w/ MD | hi - z | ETH_RXCLK<br>Ethernet Receive Clock |
| EHT7 Wire, UART4e, J1850 | hi - z | ETH_RXCLK<br>Ethernet Receive Clock |
| ETH7 Wire, J1850 | hi - z | ETH_RXCLK<br>Ethernet Receive Clock |
| UART_4, UART5e, J1850 | hi - z | ETH_RXCLK<br>Ethernet Receive Clock |
| UART5e, J1850 | hi - z | UART5e_CTS<br>Uart Clear To Send |
| J1850 | hi - z | UART5e_CTS<br>Uart Clear To Send |

**Table 2-21. Ethernet Input / Control Functions by Pin (Sheet 3 of 7)**

| PIN / BALL NUMBER | Reset Value | Description |
|---|---|---|
| **Pin ETH_10 Ball J03** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output |
| USB2 | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire | hi - z | ETH_COL<br>Ethernet Collision Detect Input |
| ETH7 Wire / USB2 | hi - z | ETH_COL<br>Ethernet Collision Detect Input |
| ETH18 Wire w/o MD | hi - z | ETH_COL<br>Ethernet Collision Detect Input |
| ETH18 Wire w/ MD | hi - z | ETH_COL<br>Ethernet Collision Detect Input |
| EHT7 Wire, UART4e, J1850 | hi - z | ETH_COL<br>Ethernet Collision Detect Input |
| ETH7 Wire, J1850 | hi - z | ETH_COL<br>Ethernet Collision Detect Input |
| UART_4, UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| J1850 | hi - z | GPIO<br>Simple General Purpose Output |

**Table 2-21. Ethernet Input / Control Functions by Pin (Sheet 4 of 7)**

| PIN / BALL NUMBER | Reset Value | Description |
|---|---|---|
| **Pin ETH_11 Ball L04** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output |
| USB2 | hi - z | GPIO<br>Simple General Purpose Output |
| ETH7 Wire | hi - z | ETH_TXCLK<br>Ethernet Transmit Clock Input |
| ETH7 Wire / USB2 | hi - z | ETH_TXCLK<br>Ethernet Transmit Clock Input |
| ETH18 Wire w/o MD | hi - z | ETH_TXCLK<br>Ethernet Transmit Clock Input |
| ETH18 Wire w/ MD | hi - z | ETH_TXCLK<br>Ethernet Transmit Clock Input |
| EHT7 Wire, UART4e, J1850 | hi - z | ETH_TXCLK<br>Ethernet Transmit Clock Input |
| ETH7 Wire, J1850 | hi - z | ETH_TXCLK<br>Ethernet Transmit Clock Input |
| UART_4, UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output |
| J1850 | hi - z | GPIO<br>Simple General Purpose Output |

**Table 2-21. Ethernet Input / Control Functions by Pin (Sheet 5 of 7)**

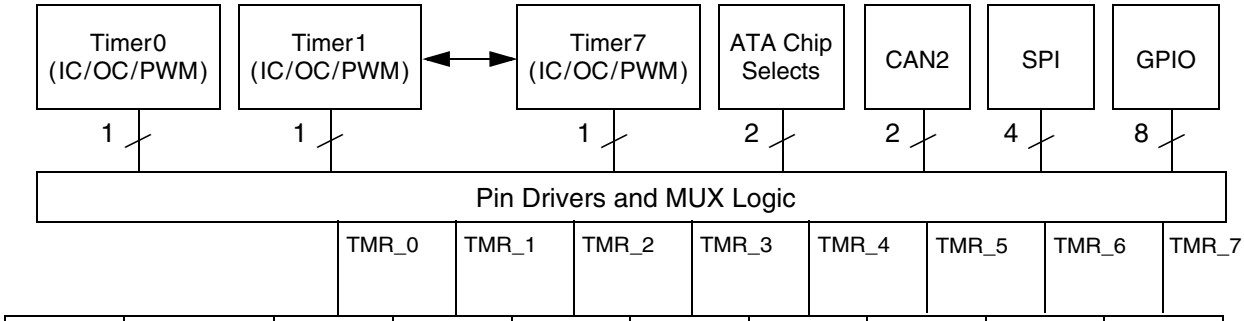
| PIN / BALL NUMBER | Reset Value | Description |
|---|---|---|
| **Pin ETH_12 Ball M02** | | |
| GPIO | hi - z | |
| USB2 | hi - z | |
| ETH7 Wire | hi - z | ETH_RXD0<br>Ethernet Receive Data Input |
| ETH7 Wire / USB2 | hi - z | ETH_RXD0<br>Ethernet Receive Data Input |
| ETH18 Wire w/o MD | hi - z | ETH_RXD0<br>Ethernet Receive Data Input |
| ETH18 Wire w/ MD | hi - z | ETH_RXD0<br>Ethernet Receive Data Input |
| EHT7 Wire, UART4e, J1850 | hi - z | ETH_RXD0<br>Ethernet Receive Data Input |
| ETH7 Wire, J1850 | hi - z | ETH_RXD0<br>Ethernet Receive Data Input |
| UART_4, UART5e, J1850 | hi - z | UART5e_RXD<br>Uart Receive Data |
| UART5e, J1850 | hi - z | UART5e_RXD<br>Uart Receive Data |
| J1850 | hi - z | — |
| **Pin ETH_13 Ball M01** | | |
| GPIO | hi - z | GPIO/INTERRUPT |
| USB2 | hi - z | USB_2_RECEIVE DIFFERENTIAL |
| ETH7 Wire | hi - z | GPIO/INTERRUPT |
| ETH7 Wire / USB2 | hi - z | USB_2_RECEIVE DIFFERENTIAL |
| ETH18 Wire w/o MD | hi - z | ETH_RXD1<br>Ethernet Receive Data Input |
| ETH18 Wire w/ MD | hi - z | ETH_RXD1<br>Ethernet Receive Data Input |
| EHT7 Wire, UART4e, J1850 | hi - z | J1850_RX<br>J1850 Receive Data |
| ETH7 Wire, J1850 | hi - z | J1850_RX<br>J1850 Receive Data |
| UART_4, UART5e, J1850 | hi - z | J1850_RX<br>J1850 Receive Data |
| UART5e, J1850 | hi - z | J1850_RX<br>J1850 Receive Data |
| J1850 | hi - z | J1850_RX<br>J1850 Receive Data |

**Table 2-21. Ethernet Input / Control Functions by Pin (Sheet 6 of 7)**

| PIN / BALL NUMBER | Reset Value | Description |
|---|---|---|
| **Pin ETH_14 Ball N04** | | |
| GPIO | hi - z | GPIO/INTERRUPT |
| USB2 | hi - z | USB_2_RXP<br>USB Receive Positive |
| ETH7 Wire | hi - z | GPIO/INTERRUPT |
| ETH7 Wire / USB2 | hi - z | USB_2_RXP<br>USB Receive Positive |
| ETH18 Wire w/o MD | hi - z | ETH_RXD2<br>Ethernet Receive Data Input |
| ETH18 Wire w/ MD | hi - z | ETH_RXD2<br>Ethernet Receive Data Input |
| EHT7 Wire, UART4e, J1850 | hi - z | UART4e_RXD<br>Uart Receive Data |
| ETH7 Wire, J1850 | hi - z | GPIO/INTERRUPT |
| UART_4, UART5e, J1850 | hi - z | UART4e_RXD<br>Uart Receive Data |
| UART5e, J1850 | hi - z | GPIO/INTERRUPT |
| J1850 | hi - z | GPIO/INTERRUPT |
| **Pin ETH_15 Ball N03** | | |
| GPIO | hi - z | GPIO/INTERRUPT |
| USB2 | hi - z | USB_2_RXN<br>USB Receive Negative |
| ETH7 Wire | hi - z | GPIO/INTERRUPT |
| ETH7 Wire / USB2 | hi - z | USB_2_RXN<br>USB Receive Negative |
| ETH18 Wire w/o MD | hi - z | ETH_RXD3<br>Ethernet Receive Data Input |
| ETH18 Wire w/ MD | hi - z | ETH_RXD3<br>Ethernet Receive Data Input |
| EHT7 Wire, UART4e, J1850 | hi - z | UART4e_CTS<br>Uart Clear To Send |
| ETH7 Wire, J1850 | hi - z | GPIO/INTERRUPT |
| UART_4, UART5e, J1850 | hi - z | UART4e_CTS<br>Uart Clear To Send |
| UART5e, J1850 | hi - z | GPIO/INTERRUPT |
| J1850 | hi - z | GPIO/INTERRUPT |

**Table 2-21. Ethernet Input / Control Functions by Pin (Sheet 7 of 7)**

| PIN / BALL NUMBER | Reset Value | Description |
|---|---|---|
| **Pin ETH_16 Ball L02** | | |
| GPIO | hi - z | GPIO/INTERRUPT |
| USB2 | hi - z | USB_2_OVRCNT<br>USB Over Current |
| ETH7 Wire | hi - z | GPIO/INTERRUPT |
| ETH7 Wire / USB2 | hi - z | USB_2_OVRCNT<br>USB Over Current |
| ETH18 Wire w/o MD | hi - z | ETH_RXERR<br>Ethernet Receive Error Input |
| ETH18 Wire w/ MD | hi - z | ETH_RXERR<br>Ethernet Receive Error Input |
| EHT7 Wire, UART4e, J1850 | hi - z | UART4e_DCD<br>Uart Carrier Detect |
| ETH7 Wire, J1850 | hi - z | GPIO/INTERRUPT |
| UART_4, UART5e, J1850 | hi - z | GPIO/INTERRUPT |
| UART5e, J1850 | hi - z | GPIO/INTERRUPT |
| J1850 | hi - z | GPIO/INTERRUPT |
| **Pin ETH_17 Ball J04** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose Output with WAKE UP |
| USB2 | hi - z | GPIO<br>Simple General Purpose Output with WAKE UP |
| ETH7 Wire | hi - z | GPIO<br>Simple General Purpose Output with WAKE UP |
| ETH7 Wire / USB2 | hi - z | GPIO<br>Simple General Purpose Output with WAKE UP |
| ETH18 Wire w/o MD | hi - z | ETH_CRS<br>Ethernet Carrier Sense Input |
| ETH18 Wire w/ MD | hi - z | ETH_CRS<br>Ethernet Carrier Sense Input |
| EHT7 Wire, UART4e, J1850 | hi - z | GPIO<br>Simple General Purpose Output with WAKE UP |
| ETH7 Wire, J1850 | hi - z | GPIO<br>Simple General Purpose Output with WAKE UP |
| UART_4, UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output with WAKE UP |
| UART5e, J1850 | hi - z | GPIO<br>Simple General Purpose Output with WAKE UP |
| J1850 | hi - z | GPIO<br>Simple General Purpose Output with WAKE UP |




| Function | Port_config [2:3_6:7] | TIMER0 | TIMER1 | TIMER2 | TIMER3 | TIMER4 | TIMER5 | TIMER6 | TIMER7 |
|---|---|---|---|---|---|---|---|---|---|
| GPIO<br>TIMER | 00_0X<br>00_10 | GPIO<br>TIMER_0 | GPIO<br>TIMER_1 | GPIO<br>TIMER_2 | GPIO<br>TIMER_3 | GPIO<br>TIMER_4 | GPIO<br>TIMER_5 | GPIO<br>TIMER_6 | GPIO<br>TIMER_7 |
| ATA_CS | 00_11 | ATA_CS_0 | ATA_CS_1 | GPIO<br>TIMER_2 | GPIO<br>TIMER_3 | GPIO<br>TIMER_4 | GPIO<br>TIMER_5 | GPIO<br>TIMER_6 | GPIO<br>TIMER_7 |
| CAN2 | 01_00 | CAN2_TX | CAN2_RX | GPIO<br>TIMER_2 | GPIO<br>TIMER_3 | GPIO<br>TIMER_4 | GPIO<br>TIMER_5 | GPIO<br>TIMER_6 | GPIO<br>TIMER_7 |
| SPI | 10_00 | GPIO<br>TIMER_0 | GPIO<br>TIMER_1 | SPI_MOSI | SPI_MISO | SPI_SS | SPI_CLK | GPIO<br>TIMER_6 | GPIO<br>TIMER_7 |
| SPI/ATA_CS | 10_11 | ATA_CS_0 | ATA_CS_1 | SPI_MOSI | SPI_MISO | SPI_SS | SPI_CLK | GPIO<br>TIMER_6 | GPIO<br>TIMER_7 |
| CAN2/SPI | 11_00 | CAN2_TX | CAN2_RX | SPI_MOSI | SPI_MISO | SPI_SS | SPI_CLK | GPIO<br>TIMER_6 | GPIO<br>TIMER_7 |

**Notes:**

1. Each pin is individually selectable as a Timer or GPIO. Each Timer can be individually configured as Input Capture (IC), Output Compare (OC), or Pulse Width Modulator (PWM) (GPT X Enable and Mode Select Register).

   If a timer pin is configured as a GPIO or some other function (SPI, chip select or CAN), the timer module can still be used internally by software.
2. Timers 6 and 7, when configured as input capture, contain WakeUp functionality.
3. All Timer and GPIO function controls are within the Timer module register set.
4. CAN RX input supports WakeUp functionality.

**Figure 2-10. Timer Port Map—8 Pins**

**Table 2-22. Timer Pin Functions**

| Pin Name | Dir. | GPIO | TIMER | ATA CHIP SEL | CAN2 | SPI | CAN2 / SPI |
|---|---|---|---|---|---|---|---|
| TIMER 0 | I/O | SIMPLE GPIO | TIMER 0 | ATA_CS_0 | CAN2_TX | SIMPLE GPIO | CAN2_TX |
| TIMER 1 | I/O | SIMPLE GPIO | TIMER 1 | ATA_CS_1 | CAN2_RX | SIMPLE GPIO | CAN2_RX |
| TIMER 2 | I/O | SIMPLE GPIO | TIMER 2 | SIMPLE GPIO | SIMPLE GPIO | SPI_MOSI | SPI_MOSI |
| TIMER 3 | I/O | SIMPLE GPIO | TIMER 3 | SIMPLE GPIO | SIMPLE GPIO | SPI_MISO | SPI_MISO |
| TIMER 4 | I/O | SIMPLE GPIO | TIMER 4 | SIMPLE GPIO | SIMPLE GPIO | SPI_SS | SPI_SS |
| TIMER 5 | I/O | SIMPLE GPIO | TIMER 5 | SIMPLE GPIO | SIMPLE GPIO | SPI_CLK | SPI_CLK |
| TIMER 6 | I/O | SIMPLE GPIO | TIMER 6 | SIMPLE GPIO | SIMPLE GPIO | SIMPLE GPIO | SIMPLE GPIO |
| TIMER 7 | I/O | SIMPLE GPIO | TIMER 7 | SIMPLE GPIO | SIMPLE GPIO | SIMPLE GPIO | SIMPLE GPIO |

**Table 2-23. Timer Functions by Pin**

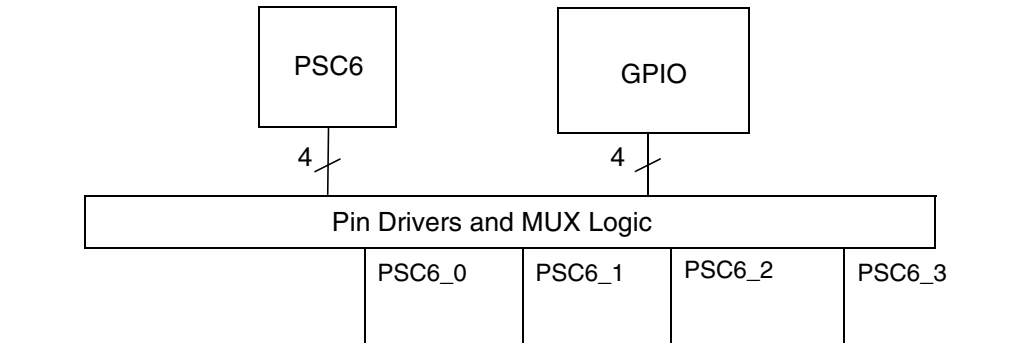
| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin TIMER_0 Ball Y20** | | |
| TIMER | hi - z | TIMER_0 |
| GPIO | hi - z | GPIO<br>Simple General Purpose I/O |
| ATA CHIP SELECTS | hi - z | ATA_CS0<br>ATA Chip Select 0 |
| CAN2 | hi - z | CAN2_TX<br>CAN 2 Transmit Data |
| SPI | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN2 / SPI | hi - z | CAN2_TX<br>CAN 2 Transmit Data |
| **Pin TIMER_1 Ball V18** | | |
| TIMER | hi - z | TIMER_1 |
| GPIO | hi - z | GPIO<br>Simple General Purpose I/O |
| ATA CHIP SELECTS | hi - z | ATA_CS0<br>ATA Chip Select 1 |
| CAN2 | hi - z | CAN2_RX<br>CAN 2 Receive Data |
| SPI | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN2 / SPI | hi - z | CAN2_RX<br>CAN 2 Receive Data |

**Table 2-23. Timer Functions by Pin (continued)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin TIMER_2 Ball D03** | | |
| TIMER | hi - z | TIMER_2 |
| GPIO | hi - z | GPIO<br>Simple General Purpose I/O |
| ATA CHIP SELECTS | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN2 | hi - z | GPIO<br>Simple General Purpose I/O |
| SPI | hi - z | SPI _MOSI<br>SPI Master Out Slave In |
| CAN2 / SPI | hi - z | SPI MOSI<br>SPI Master Out Slave In |
| **Pin TIMER_3 Ball D02** | | |
| TIMER | hi - z | TIMER_3 |
| GPIO | hi - z | GPIO<br>Simple General Purpose I/O |
| ATA CHIP SELECTS | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN2 | hi - z | GPIO<br>Simple General Purpose I/O |
| SPI | hi - z | SPI _MISO<br>SPI Master In Slave Out |
| CAN2 / SPI | hi - z | SPI MISO<br>SPI Master In Slave Out |
| **Pin TIMER_4 Ball D01** | | |
| TIMER | hi - z | TIMER_4 |
| GPIO | hi - z | GPIO<br>Simple General Purpose I/O |
| ATA CHIP SELECTS | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN2 | hi - z | GPIO<br>Simple General Purpose I/O |
| SPI | hi - z | SPI _SS<br>SPI Slave Select |
| CAN2 / SPI | hi - z | SPI SS<br>SPI Slave Select |

**Table 2-23. Timer Functions by Pin (continued)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin TIMER_5 Ball E03** | | |
| TIMER | hi - z | TIMER_5 |
| GPIO | hi - z | GPIO<br>Simple General Purpose I/O |
| ATA CHIP SELECTS | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN2 | hi - z | GPIO<br>Simple General Purpose I/O |
| SPI | hi - z | SPI _CLK<br>SPI Clock |
| CAN2 / SPI | hi - z | SPI CLK<br>SPI Clock |
| **Pin TIMER_6 Ball E02** | | |
| TIMER | hi - z | TIMER_6 |
| GPIO | hi - z | GPIO<br>Simple General Purpose I/O |
| ATA CHIP SELECTS | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN2 | hi - z | GPIO<br>Simple General Purpose I/O |
| SPI | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN2 / SPI | hi - z | GPIO<br>Simple General Purpose I/O |
| **Pin TIMER_7 Ball E01** | | |
| TIMER | hi - z | TIMER_7 |
| GPIO | hi - z | GPIO<br>Simple General Purpose I/O |
| ATA CHIP SELECTS | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN2 | hi - z | GPIO<br>Simple General Purpose I/O |
| SPI | hi - z | GPIO<br>Simple General Purpose I/O |
| CAN2 / SPI | hi - z | GPIO<br>Simple General Purpose I/O |




| Function | Port_conf [9:11] | PSC6_0 | PSC6_1 | PSC6_2 | PSC6_3 |
|---|---|---|---|---|---|
| GPIO | 000 | GPIO_W/WAKE_UP | GPIO_W/WAKE_UP | GPIO | GPIO |
| UART6/ IrDA | 101 | UART6_RXD/ IrDA_RX | UART6_CTS | UART6_TXD/ IrDA_TX | UART6_RTS |
| CODEC6/ IrDA | 111 | CODEC6_RXD/ IrDA_RX | CODEC6_FRAME | CODEC6_TXD/ IrDA_TX | CODEC6_CLK/ IR_USB_CLK |

**Figure 2-11. PSC6 Port Map—4 Pins**

**Table 2-24. PSC6 Pin Functions**

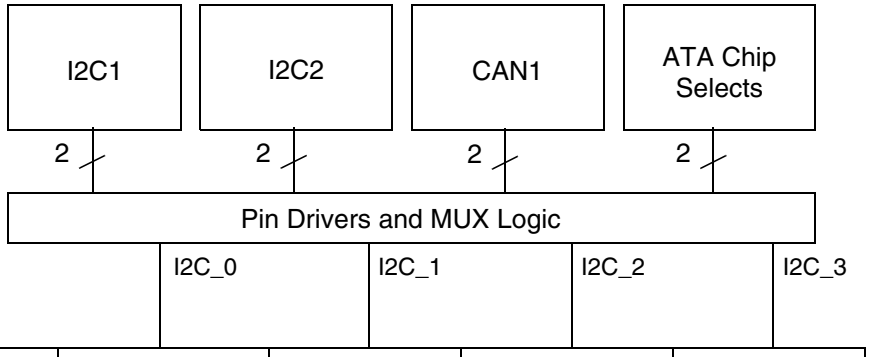
| Pin Name | Dir. | GPIO | UART6/ IrDA | CODEC6 / IrDA |
|---|---|---|---|---|
| PSC6_0 | I/O | WAKE_UP | UART6_RXD<br>IrDA_RX | CODEC6_RXD<br>Irda_RX |
| PSC6_1 | I/O | WAKE_UP | UART6_CTS | CODEC6_FRAME |
| PSC6_2 | I/O | SIMPLE GPIO | UART6_TXD<br>IrDA_TX | CODEC6_TXD<br>IrDA_TX |
| PSC6_3 | I/O | SIMPLE GPIO | UART6_RTS | CODEC6_CLK/<br>IR_USB_CLK |

**Table 2-25. PSC6 Functions by Pin**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin PSC6_0 Ball B12** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose I/O with WAKE UP |
| UART6 / IrDA | hi - z | UART6_RXD<br>Uart Receive Data<br>IrDA_RX IrDA Receive Data |
| CODEC6 / IrDA | hi - z | CODEC6_RXD<br>CODEC Receive Data<br>IrDA_RX IrDA Receive Data |

**Table 2-25. PSC6 Functions by Pin (continued)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin PSC6_1 Ball C11** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose I/O with WAKE UP |
| UART6 | hi - z | UART6_CTS<br>Uart Clear To Send |
| CODEC6 | hi - z | CODEC6_FRAME<br>CODEC Frame Sync |
| **Pin PSC6_2 Ball A12** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose I/O |
| UART6 / IrDA | hi - z | UART6_TXD<br>Uart Transmit Data<br>IrDA_TX Irda Transmit Data |
| CODEC6 / IrDA | hi - z | CODEC6_TXD<br>CODEC Transmit Data<br>IrDA_TX Irda Transmit Data |
| **Pin PSC6_3 Ball C13** | | |
| GPIO | hi - z | GPIO<br>Simple General Purpose I/O |
| UART6 | hi - z | UART6_RTS<br>Uart Clear To Send |
| CODEC6 / IrDA | hi - z | CODEC6_CLK<br>IR_USB_CLK |




| Function | Port_conf | I2C_0 | I2C_1 | I2C_2 | I2C_3 |
|---|---|---|---|---|---|
| I2C1 / I2C2 | default | I2C1_CLK | I2C1_IO | I2C2_CLK | I2C2_IO |
| CAN1 / I2C2 | Port_conf[2:3]=01 | CAN1_TX | CAN1_RX | I2C2_CLK | I2C2_IO |
| I2C1 / ATA CHIP SELECTS | Port_conf[6:7]=10 | I2C1_CLK | I2C1_IO | ATA_CS_0 | ATA_CS_1 |

**Note:**

1. CAN RX input supports WakeUp functionality.

**Figure 2-12. $I^2C$ Port Map—4 Pins (two pins each, for two $I^2Cs$)**

**Table 2-26. $I^2C$ Functions by Pin**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| **Pin I2C_0 Ball V19** | | |
| I2C_1 / I2C_2 | | I2C_1_CLK<br>I2C Clock |
| CAN_1/I2C_2 | | CAN1_TX<br>CAN Transmit Data |
| I2C_1/ATA_CS | | I2C_1_CLK<br>I2C Clock |
| **Pin I2C_1 Ball W19** | | |
| I2C_1 / I2C_2 | | I2C_1_I/O |
| CAN1/CAN2 | | CAN1_RX |
| I2C_1/ATA_CS | | I2C_1_I/O |
| **Pin I2C_2 Ball V20** | | |
| I2C_1 / I2C_2 | | I2C_2_CLK<br>I2C Clock |
| CAN1/CAN2 | | I2C_2_CLK<br>I2C Clock |
| I2C_1/ATA_CS | | ATA_CS0<br>ATA Chip Select 0 |
| **Pin I2C_3 Ball W20** | | |
| I2C_1 / I2C_2 | | I2C_2_I/O<br>I2C I/O line |
| CAN1/CAN2 | | I2C_2_I/O<br>I2C I/O line |
| I2C_1/ATA_CS | | ATA_CS1<br>ATA Chip Select 1 |

**Table 2-27. SDRAM Bus Pin Functions (Sheet 1 of 4)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| Pin MEM_RAS<br>Ball A18 | logic 0 | SDRAM Bus Row Address Strobe |
| Pin MEM_CAS<br>Ball B19 | logic 0 | SDRAM Bus Column Address Strobe |
| Pin $\overline{\text{MEM\_WE}}$<br>Ball A19 | logic 0 | SDRAM Bus Write enable |
| Pin $\overline{\text{MEM\_CS\_0}}$<br>Ball B18 | logic 1 | SDRAM Bus Chip Select 0 |
| Pin $\overline{\text{MEM\_CS\_1}}$<br>Ball C15 (GPIO_WKUP_6) | logic 1 | SDRAM Bus Chip Select 1<br>(shared with GPIO_WKUP_6) |
| Pin MEM_CLK_EN<br>Ball F20 | logic 0 | SDRAM Bus Clock Enable |
| Pin MEM_CLK<br>Ball G19 | logic 0 | SDRAM Bus Memory Clock |
| Pin $\overline{\text{MEM\_CLK}}$<br>Ball G20 | logic 1 | SDRAM Bus Inverted Memory Clock |
| Pin MEM_MBA_1<br>Ball A17 | logic 0 | SDRAM Bus Memory Bank Address 1 |
| Pin MEM_MBA_0<br>Ball C18 | logic 0 | SDRAM Bus Memory Bank Address 0 |
| Pin MEM_MDQS_3<br>Ball L18 | hi - z | SDRAM Bus Bidirectional Data Bus Strobe 3 |
| Pin MEM_MDQS_2<br>Ball D18 | hi - z | SDRAM Bus Bidirectional Data Bus Strobe 2 |
| Pin MEM_MDQS_1<br>Ball H20 | hi - z | SDRAM Bus Bidirectional Data Bus Strobe 1 |
| Pin MEM_MDQS_0<br>Ball N20 | hi - z | SDRAM Bus Bidirectional Data Bus Strobe 0 |
| Pin MEM_DQM_3<br>Ball L17 | | SDRAM Bus Data Mask 3 |
| Pin MEM_DQM_2<br>Ball A20 | | SDRAM Bus Data Mask 2 |
| Pin MEM_DQM_1<br>Ball H19 | | SDRAM Bus Data Mask 1 |
| Pin MEM_DQM_0<br>Ball N19 | | SDRAM Bus Data Mask 0 |
| Pin MEM_MA_12<br>Ball F19 | logic 0 | SDRAM Bus Memory Address 12 |
| Pin MEM_MA_11<br>Ball E20 | logic 0 | SDRAM Bus Memory Address 11 |

**Table 2-27. SDRAM Bus Pin Functions (Sheet 2 of 4)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| Pin MEM_MA_10<br>Ball B17 | logic 0 | SDRAM Bus Memory Address 10 |
| Pin MEM_MA_9<br>Ball E19 | logic 0 | SDRAM Bus Memory Address 9 |
| Pin MEM_MA_8<br>Ball D20 | logic 0 | SDRAM Bus Memory Address 8 |
| Pin MEM_MA_7<br>Ball D19 | logic 0 | SDRAM Bus Memory Address 7 |
| Pin MEM_MA_6<br>Ball C20 | logic 0 | SDRAM Bus Memory Address 6 |
| Pin MEM_MA_5<br>Ball C19 | logic 0 | SDRAM Bus Memory Address 5 |
| Pin MEM_MA_4<br>Ball B20 | logic 0 | SDRAM Bus Memory Address 4 |
| Pin MEM_MA_3<br>Ball C16 | logic 0 | SDRAM Bus Memory Address 3 |
| Pin MEM_MA_2<br>Ball B16 | logic 0 | SDRAM Bus Memory Address 2 |
| Pin MEM_MA_1<br>Ball A16 | logic 0 | SDRAM Bus Memory Address 1 |
| Pin MEM_MA_0<br>Ball C17 | logic 0 | SDRAM Bus Memory Address 0 |
| Pin MEM_MDQ_31<br>Ball U18 | hi - z | SDRAM Bus Data 31 |
| Pin MEM_MDQ_30<br>Ball T18 | hi - z | SDRAM Bus Data 30 |
| Pin MEM_MDQ_29<br>Ball R18 | hi - z | SDRAM Bus Data 29 |
| Pin MEM_MDQ_28<br>Ball R17 | hi - z | SDRAM Bus Data 28 |
| Pin MEM_MDQ_27<br>Ball P18 | hi - z | SDRAM Bus Data 27 |
| Pin MEM_MDQ_26<br>Ball N18 | hi - z | SDRAM Bus Data 26 |
| Pin MEM_MDQ_25<br>Ball N17 | hi - z | SDRAM Bus Data 25 |
| Pin MEM_MDQ_24<br>Ball M18 | hi - z | SDRAM Bus Data 24 |
| Pin MEM_MDQ_23<br>Ball K18 | hi - z | SDRAM Bus Data 23 |

**Table 2-27. SDRAM Bus Pin Functions (Sheet 3 of 4)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| Pin MEM_MDQ_22<br>Ball J17 | hi - z | SDRAM Bus Data 22 |
| Pin MEM_MDQ_21<br>Ball J18 | hi - z | SDRAM Bus Data 21 |
| Pin MEM_MDQ_20<br>Ball H18 | hi - z | SDRAM Bus Data 20 |
| Pin MEM_MDQ_19<br>Ball G18 | hi - z | SDRAM Bus Data 19 |
| Pin MEM_MDQ_18<br>Ball G17 | hi - z | SDRAM Bus Data 18 |
| Pin MEM_MDQ_17<br>Ball F18 | hi - z | SDRAM Bus Data 17 |
| Pin MEM_MDQ_16<br>Ball E18 | hi - z | SDRAM Bus Data 16 |
| Pin MEM_MDQ_15<br>Ball M20 | hi - z | SDRAM Bus Data 15 |
| Pin MEM_MDQ_14<br>Ball M19 | hi - z | SDRAM Bus Data 14 |
| Pin MEM_MDQ_13<br>Ball L20 | hi - z | SDRAM Bus Data 13 |
| Pin MEM_MDQ_12<br>Ball L19 | hi - z | SDRAM Bus Data 12 |
| Pin MEM_MDQ_11<br>Ball K20 | hi - z | SDRAM Bus Data 11 |
| Pin MEM_MDQ_10<br>Ball K19 | hi - z | SDRAM Bus Data 10 |
| Pin MEM_MDQ_9<br>Ball J20 | hi - z | SDRAM Bus Data 9 |
| Pin MEM_MDQ_8<br>Ball J19 | hi - z | SDRAM Bus Data 8 |
| Pin MEM_MDQ_7<br>Ball P19 | hi - z | SDRAM Bus Data 7 |
| Pin MEM_MDQ_6<br>Ball **P20** | hi - z | SDRAM Bus Data 6 |
| Pin MEM_MDQ_5<br>Ball R19 | hi - z | SDRAM Bus Data 5 |
| Pin MEM_MDQ_4<br>Ball R20 | hi - z | SDRAM Bus Data 4 |
| Pin MEM_MDQ_3<br>Ball T19 | hi - z | SDRAM Bus Data 3 |

**Table 2-27. SDRAM Bus Pin Functions (Sheet 4 of 4)**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| Pin MEM_MDQ_2<br>Ball T20 | hi - z | SDRAM Bus Data 2 |
| Pin MEM_MDQ_1<br>Ball U19 | hi - z | SDRAM Bus Data 1 |
| Pin MEM_MDQ_0<br>Ball U20 | hi - z | SDRAM Bus Data 0 |
| Pin MEM_RDCLK<br>Ball not pinned out | clk | SDRAM Bus Memory Read Clock<br>(not pinned out) |

**Table 2-28. JTAG and Test Pin Functions**

| Pin / Ball Number | Reset Value | Description |
|---|---|---|
| Pin JTAG_TCK<br>Ball B04 | | JTAG Test Clock |
| Pin JTAG_TMS<br>Ball A04 | | JTAG Test Mode Select |
| Pin JTAG_TDI<br>Ball A03 | | JTAG Test Data In |
| Pin $\overline{\text{JTAG\_TRST}}$<br>Ball B03 | | JTAG Reset |
| Pin JTAG_TDO<br>Ball A02 | | JTAG Test Data Out |
| Pin TEST_MODE_0<br>Ball B02 | | Test Mode Select 0 (for production test)<br>NOTE: This pin requires a pull-down resistor. |
| Pin TEST_MODE_1<br>Ball A01 | | Test Mode Select 1 (for production test)<br>NOTE: This pin requires a pull-down resistor. |
| Pin TEST_SEL_0<br>Ball B01 | | Scan Enable (for production test), PLL_BYPASS - input, CK_STOP - output |
| Pin TEST_SEL_1<br>Ball C03 | | ENID Input in Test Mode (for production test)<br>NOTE: This pin requires a pull-down resistor. |

**Table 2-29. CLOCK / RESET Pin Functions**

| Clock / Reset | Reset Value | Description |
|---|---|---|
| Pin $\overline{\text{PORRESET}}$<br>Ball A13 | logic 1 | Power On Reset |
| Pin $\overline{\text{HRESET}}$<br>Ball B13 | logic 1 | Hard Reset |
| Pin $\overline{\text{SRESET}}$<br>Ball A14 | logic 1 | Soft Reset |
| Pin SYS_XTAL_IN<br>Ball A15 | | APLL Chip clock crystal / external clock input |
| Pin SYS_XTAL_OUT<br>Ball D14 | clk | APLL Chip Clock Crystal |
| Pin SYS_PLL_TPA<br>Ball B15 | | MPC5200B System Test Pll Output (analog output) |

**Table 2-30. Dedicated GPIO Pin Function**

| Dedicated GPIO | Reset Value | Description |
|---|---|---|
| **Pin GPIO_WKUP_6 Ball C15** | | |
| GPIO Wakeup | logic 0 | Asynchronous GPIO with Wakeup Capability GPIO_WKUP_6 |
| Memory Chip Select | logic 0 | SDRAM Chip Select 1 |
| **Pin GPIO_WKUP_7 Ball C12** | | |
| GPIO Wakeup | hi - z | Asynchronous GPIO with Wakeup Capability GPIO_WKUP_7 |
| LocalPlus MOST/Graphics TSIZ | hi - z | TSIZ1 for LocalPlus MOST/GRAPHICS mode |

**Table 2-31. Systems Integration Unit Pin Functions**

| Systems Integration Unit | Reset Value | Descriptions |
|---|---|---|
| Pin $\overline{\text{LP\_CS0}}$<br>Ball W14 | logic 1 | LocalPlus Bus Chip Select 0 |
| Pin $\overline{\text{LP\_CS1}}$<br>Ball Y14 | logic 1 | LocalPlus Bus Chip Select 1 |
| Pin $\overline{\text{LP\_CS2}}$<br>Ball V15 | logic 1 | LocalPlus Bus Chip Select 2 |
| Pin $\overline{\text{LP\_CS3}}$<br>Ball W15 | logic 1 | LocalPlus Bus Chip Select 3 |
| Pin $\overline{\text{LP\_CS4}}$<br>Ball Y15 | logic 1 | LocalPlus Bus Chip Select 4 |
| Pin $\overline{\text{LP\_CS5}}$<br>Ball V16 | logic 1 | LocalPlus Bus Chip Select 5 |
| Pin $\overline{\text{LP\_OE}}$<br>Ball D08 | logic 1 | LocalPlus Bus Output Enable |
| Pin $\overline{\text{IRQ0}}$<br>Ball P03 | | External Interrupt 0 |
| Pin $\overline{\text{IRQ1}}$<br>Ball P01 | | External Interrupt 1 |
| Pin $\overline{\text{IRQ2}}$<br>Ball P02 | | External Interrupt 2 |
| Pin $\overline{\text{IRQ3}}$<br>Ball R01 | | External Interrupt 3 |
| Pin RTC_XTAL_IN<br>Ball C02 | | Real Time Clock Crystal Input / External Clock Input |
| Pin RTC_XTAL_OUT<br>Ball C01 | | Real Time Clock Crystal Output |

# Chapter 3
# Memory Map

## 3.1 Overview

The following sections are contained in this document:

- MPC5200B Internal Register Memory Map
- MPC5200B Memory Map
- SDRAM Bus
- LocalPlus Bus
  - — Memory Cycles
    - – Boot Chip Select
    - – Chip Selects
  - — ATA Cycles
  - — PCI Cycles
- MPC5200B Register Summaries
  - — Memory Map Registers — MBAR + 0x0000
  - — SDRAM Registers — MBAR + 0x0100
  - — Clock Distribution Module Registers — MBAR + 0x0200
  - — Chip Select Configuration Registers — MBAR + 0x0300
  - — Interrupt Controller Registers — MBAR + 0x0500
  - — General Purpose Timer Registers — MBAR + 0x0600
  - — Slice Timer Control Registers — MBAR + 0x0700
  - — Real Time Clock Registers — MBAR + 0x0800
  - — MSCAN Registers — MBAR + 0x0900
  - — Simple GPIO Registers — MBAR + 0x0B00
  - — Wake-up GPIO Registers — MBAR + 0x0C00
  - — PCI Registers — MBAR + 0x0D00
  - — Serial Peripheral Interface Registers — MBAR + 0x0F00
  - — USB Host Registers — MBAR + 0x1000
  - — BestComm Registers — MBAR + 0x1200
  - — J1850 (BDLC Controller) Registers — MBAR + 0x1300
  - — XL BUS ARbitration Registers — MBAR + 0x1F00
  - — PSC1 Registers — MBAR + 0x2000
  - — PSC2 Registers — MBAR + 0x2200
  - — PSC3 Registers — MBAR + 0x2400
  - — PSC4 Registers — MBAR + 0x2600

— PSC5 Registers — MBAR + 0x2800
— PSC6 Registers — MBAR + 0x2C00
— Ethernet Registers — MBAR + 0x3000
— BestComm / PCI Interface Registers — MBAR + 0x3800
— ATA Bus Configuration Registers — MBAR + 0x3A00
— BestComm / LocalPlus Interface Registers — MBAR + 0x3C00
— I2C Configuration Registers — MBAR + 0x3D00
— SRAM Module — MBAR + 0x8000

## 3.2 Internal Register Memory Map

**Table 3-1. Internal Register Memory Map**

| Address | Name | Description | Reference |
|---|---|---|---|
| MBAR + 0x0000 | MM | Memory Map Registers | Section 3.3.3 |
| MBAR + 0x0100 | SDRAM | SDRAM Memory Controller registers. | Section 8.6.1 |
| MBAR + 0x0200 | CDM | Clock Distribution Module registers. | Section 5.5 |
| MBAR + 0x0300 | CSC | Chip Select Controller registers. | Section 9.7.1 |
| MBAR + 0x0500 | ICTL | Interrupt Controller registers. | Section 7.2.4 |
| MBAR + 0x0600 | GPT | General Purpose Timer registers. | Section 7.4.4 |
| MBAR + 0x0700 | SLT | Slice Time registers. | Section 7.5.1 |
| MBAR + 0x0800 | RTC | Real-Time Clock registers. | Section 7.6.3 |
| MBAR + 0x0900 | CAN | MSCAN registers. | Section 19.5.2 |
| MBAR + 0x0B00 | GPS | GPIO Standard registers | Section 7.3.2.1 |
| MBAR + 0x0C00 | GPW | GPIO Wake up registers. | Section 7.3.2.2 |
| MBAR + 0x0D00 | PCI | PCI XLB Configuration registers | Section 10.3 |
| MBAR + 0x0F00 | SPI | Serial Peripheral Interface registers. | Section 17.3 |
| MBAR + 0x1000 | USB | Universal Serial Bus registers. | Section 12.4 |
| MBAR + 0x1200 | BDMA | BestComm DMA registers. | Section 13.15 |
| MBAR + 0x1300 | BDLC | J1850 (BDLC) registers | Section 20.7 |
| MBAR + 0x1F00 | XLARB | XL BUS ARBITRATION Registers | Section 16.2.1 |
| MBAR + 0x2000 | PSC1 | Programmable Serial Controller 1 registers. | Section 15.2.2 |
| MBAR + 0x2200 | PSC2 | Programmable Serial Controller 2 registers. | Section 15.2.2 |
| MBAR + 0x2400 | PSC3 | Programmable Serial Controller 3 registers. | Section 15.2.2 |
| MBAR + 0x2600 | PSC4 | Programmable Serial Controller 4 registers. | Section 15.2.2 |
| MBAR + 0x2800 | PSC5 | Programmable Serial Controller 5 registers. | Section 15.2.2 |
| MBAR + 0x2C00 | PSC6 | Programmable Serial Controller 6 / Infrared Data Association registers. | Section 15.2.2 |
| MBAR + 0x3000 | ETH | Ethernet registers. | Section 14.4.3 |
| MBAR + 0x3800 | BPCI | BestComm DMA PCI registers. | Section 10.3.3 |

**Table 3-1. Internal Register Memory Map (continued)**

| Address | Name | Description | Reference |
|---|---|---|---|
| MBAR + 0x3A00 | ATA | Advanced Technology Attachment registers. | Section 11.3.1<br>Section 11.3.2<br>Section 11.3.3 |
| MBAR + 0x3C00 | BLPC | BestComm DMA LocalPlus registers | Section 9.7.2 |
| MBAR + 0x3D00 | $I^2C$ | Inter-Integrated Circuit registers. | Section 18.3 |
| MBAR + 0x8000 | SRAM | On-chip Static RAM memory locations. | Section 13.16 |

## 3.3 MPC5200B Memory Map

The MPC5200B memory map has the following main regions:

- MPC5200B Internal Register Space
- External Busses
  - — SDRAM Bus
  - — LocalPlus Bus
    - – External Chip Selects 0–7
    - – Memory Space
    - – Boot Space
    - – Program Space
    - – Data Space
- ATA Space

### 3.3.1 MPC5200B Internal Register Space

The internal registers of the MPC5200B are memory mapped, just like external RAM or any other peripheral devices. The addresses of the internal registers are expressed as offsets to the contents of the MBAR Register (Memory Base Address Register).

The Memory Base Address Register contains the upper 16 bits of the register address space. This sixteen bit value is contained in the lower 16 bits (bit 16 - bit 31) of the Memory Base Address Register. The default value at the release of RESET contained in the MBAR Register is 0x0000 8000. To form a register address, the lower sixteen bits of MBAR are left-justified, forming address bits A31 - A16. Then the 16-bit register offset address for a particular register is concatenated with this value to form a 32-bit address.

**NOTE**

On the LocalPlus Bus, A31 is the Most Significant Bit and A0 is the Least Significant Bit. It is most important to note that the internal registers of the MPC5200B use bit 0 as the Most Significant Bit and bit 31 as the Least Significant Bit.

**NOTE**

The Memory Base Address Register is memory mapped, itself, and it is also the first register in the Internal Register Space. Because the default value in MBAR from the release of RESET is 0x0000 8000 and the MBAR register has an offset address of 0x0000 0000, the absolute address of MBAR becomes 0x8000 0000.

For an additional example, the offset addresses of the Clock Distribution Module Registers start at 0x0200. Using the default value in MBAR, the address of the first register in the Clock Distribution Module is 0x8000 0200.

**NOTE**

The MBAR register is a memory mapped register. In fact, the contents of the MBAR register hold the Most Significant 16 bits of its own address. When the contents of the MBAR register are changed, a copy of this value should be written to Special Purpose Register SPR (0d311). This location should be used to store the present Memory Base Address for the System Memory map. It is the responsibility of the system programmer to ensure the present value is current with the system's memory base offset.

## 3.3.2 External Busses

There are two external data / address bus structures on the MPC5200B. These are the LocalPlus Bus and the SDRAM Bus. The MPC5200B always begins execution from the release of RESET on the LocalPlus Bus and from the memory device connected to $\overline{\text{LP\_CS0}}$.

### 3.3.2.1 SDRAM Bus

The SDRAM BUS is designed to accommodate Synchronous Single Data Rate DRAM and Synchronous Double Data Rate DRAM. Program execution generally occurs from programs stored in the memory located on the SDRAM Bus. The SDRAM bus has burst read capability which greatly enhances the bandwidth of the SDRAM Bus. The Memory Clock that drives the SDRAM bus is equal to the XL Bus clock frequency.

From Power On Reset the SDRAM Bus is inactive, that is, the chip select line for the SDRAMs is inactive. The appropriate registers must first be programmed to configure the SDRAM Bus chip select line and make it active before program execution can begin on the SDRAM bus. In general, when a system begins operation from a Power On Reset, "programs stored as data" in memory devices on the LocalPlus Bus are transferred to the SDRAM bus memory by a program stored in the Boot Device on the LocalPlus Bus. Once the "programs stored as data" are transferred to the SDRAM bus memory, the Boot program then causes the CPU to jump to the start address of the program which is now located in SDRAM Bus memory and execution continues from the SDRAM Bus memory.

### 3.3.2.2 LocalPlus Bus

The LocalPlus Bus is designed to connect to ROM, FLASH, static RAM and other peripheral devices. It is not designed to accommodate DRAM's. Program execution begins from the LocalPlus Bus memory device connected to LP_CS0. In actual practice, the only programs that are usually executed from LocalPlus Bus memory are those used to initialize the MPC5200B and to transfer data from LocalPlus Bus memory to SDRAM bus memory. In general, programs are stored as data in non-volatile memory on the LocalPlus Bus and then transferred to the SDRAM Bus. Once the transfer occurs, program execution is transferred to a program residing in memory on the SDRAM Bus.

The LocalPlus Bus can be accessed by the CPU to perform direct reads and writes of external memory or the LocalPlus Bus can be a BestComm Peripheral. In this case, the CPU programs the BestComm Controller to automatically transfer data from a particular source address to the LocalPlus memory or from the LocalPlus memory to a particular destination address. Almost all peripheral modules, such as the PSC modules, and both the SDRAM Bus and LocalPlus Bus can be BestComm data sources or destinations.

There are 8 chip select lines, CS0 - CS7, associated with the LocalPlus Bus. Also, there are three basic memory access types that can be run on the LocalPlus bus. These are normal memory accesses, PCI cycles and ATA cycles.

The LocalPlus LP_CS0 pin can have two configurations. It can be the BOOT Chip Select line, which is its default condition from the release of RESET, and it can be configured after RESET to be LP_CS0. When configured as the BOOT Chip Select, this chip select line can select Program Space. Thus, program execution can occur from the memory device selected by LP_CS0. If the LP_CS0 pin is configured for data space by user software, then only Data Space Memory can be read or written.

Associated with each Chip Select line is a Start Address Register and a Stop Address Register. There are two Chip Select Start/Stop Address Register pairs associated with the LP_CS0 pin. One Chip Select Start/Stop Register pair is used to configure the LP_CS0 pin as the BOOT Chip Select and the other register pair configures the LP_CS0 pin to run normal memory access cycles in data space, only. Only one of the LP_CS0 Chip Select Start/Stop Address Register pairs should be active at any given time.

When enabled as the Boot Chip Select, only reads are possible. Reads of 64-bits are supported for instruction fetches. Burst reads are also supported. When enabled as a data space memory chip select, only Data Space reads and writes are supported. Code cannot be executed from a memory device connected to LP_CS0 when it is configured as a data space chip select. Bursting is not supported and reads are limited to 32-bits.

There are two additional Start/Stop Address Register pairs used for PCI cycles. These registers are not associated with any chip select line. Chip Select 4 and Chip Select 5 can be configured to run normal memory cycles or ATA cycles. Chip Select 1 - 3 and Chip Select 6 - 7 can only run normal memory cycles.

All the address related registers in this module are in the form of Start/Stop pairs. An address appearing on XL Bus is compared as equal-to-or-greater than the Start value and less-than-or-equal-to the Stop value. If both tests pass then a valid address "hit" occurs for the associated space. For Start values the unused bits are assumed to be zero, for Stop values the unused bits are assumed to be high.

Address registers (and the MBAR itself) have only 16 significant bits. Although these bits are right-justified in the registers they are actually interpreted as the most significant 16 bits of the address for comparison tests. For this reason, software must right shift an absolute address by 16 before writing it as a value into the desired START or STOP Address register. The same is true when reading values from these registers.

Start/Stop comparisons are enabled only if the corresponding enable bit in the MM Address Space Enable Register is high. The proper method for updating Start/Stop registers is to first write the enable bit to zero, update both the Start and Stop registers, and then re-enable the corresponding enable bit by writing it high.

**NOTE**

Failure to follow the above procedure could result in bus hanging and machine check errors.

## 3.3.3 Memory Map Space Register Description

These registers exist in the Memory Map register space relative to Memory Base Address Register (MBAR).

### 3.3.3.1 Memory Address Base Register

Address MBAR + 0x0000

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Base Address Register | | | | | | | | | | | | | | | |
| Reset | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 3-1. Memory Address Base Register**

**Table 3-2. Memory Address Base Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:15 | Reserved | These bits are reserved. |
| 16:31 | Base Address Register | Provides the offset to which all register space for MPC5200B is accessed. The reset value of this register is 0x8000, which provides for a MBAR of 0x8000 0000. All of MPC5200B registers are then accessible at MBAR+offset, where offset refers to the given value in <Cross Refs Helv 9>Table 3-1 for the respective module. |

### 3.3.3.2 Boot and Chip Select Addresses

**Table 3-3. Boot and Chip Select Address Registers**

| MBAR offset | Name | Description |
|---|---|---|
| 0x0004 | CS0 Start Address | Chip Select 0 through the LocalPlus Bus. Any access on an address between the Start and Stop Addresses enables this chip select. |
| 0x0008 | CS0 Stop Address | |
| 0x000C | CS1 Start Address | Chip Select 1 through the LocalPlus Bus. Any access on an address between the Start and Stop Addresses enables this chip select. |
| 0x0010 | CS1 Stop Address | |
| 0x0014 | CS2 Start Address | Chip Select 2 through the LocalPlus Bus. Any access on an address between the Start and Stop Addresses enables this chip select. |
| 0x0018 | CS2 Stop Address | |
| 0x001C | CS3 Start Address | Chip Select 3 through the LocalPlus Bus. Any access on an address between the Start and Stop Addresses enables this chip select. |
| 0x0020 | CS3 Stop Address | |
| 0x0024 | CS4 Start Address | Chip Select 4 through the LocalPlus Bus. Any access on an address between the Start and Stop Addresses enables this chip select. |
| 0x0028 | CS4 Stop Address | |
| 0x002C | CS5 Start Address | Chip Select 5 through the LocalPlus Bus. Any access on an address between the Start and Stop Addresses enables this chip select. |
| 0x0030 | CS5 Stop Address | |
| 0x004C | Boot Start Address | Boot Addressing through the LocalPlus Bus. Any access on an address between the Start and Stop Addresses accesses the boot space. By default, the address space accessed starts at 0x0000 0000 or 0xFFF0 0000 depends on the reset configuration. The size of the boot address space after reset is 512Kbytes. |
| 0x0050 | Boot Stop Address | |
| 0x0058 | CS6 Start Address | Chip Select 6 through the LocalPlus Bus. Any access on an address between the Start and Stop Addresses enables this chip select. |
| 0x005C | CS6 Stop Address | |
| 0x0060 | CS7 Start Address | Chip Select 7 through the LocalPlus Bus. Any access on an address between the Start and Stop Addresses enables this chip select. |
| 0x0064 | CS7 Stop Address | |

All of these Base Address Registers work the same

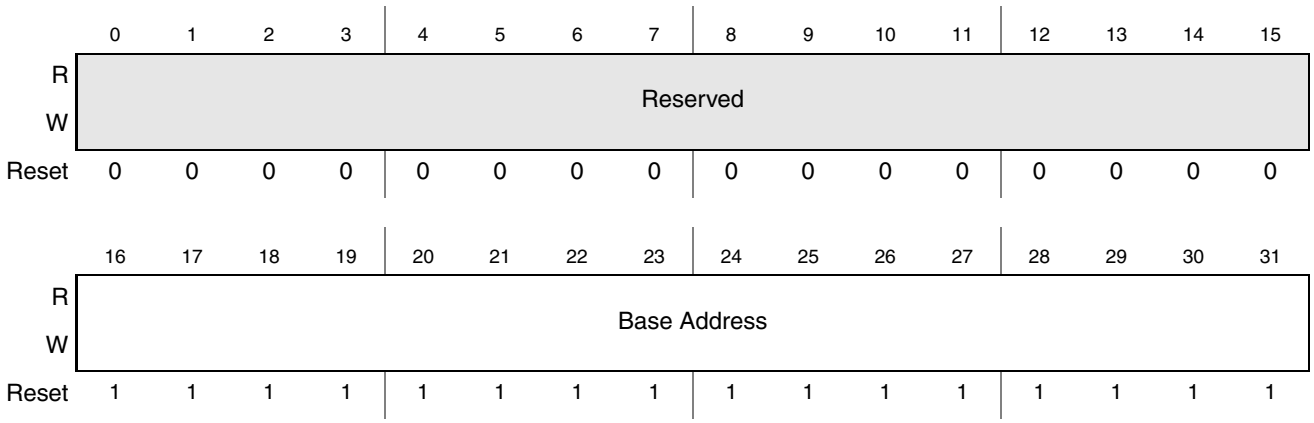



**Figure 3-2. Boot and Chip Select Address Register**

**Table 3-4. Boot and Chip Select Address Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:15 | Reserved | These bits are reserved. |
| 16:31 | Base Address | The 16 most significant bits of the Base Address. A value of 0x4000 would translate into a base address of 0x4000 0000. |

### 3.3.3.3 SDRAM Chip Select Configuration Registers

**Table 3-5. SDRAM Chip Select Configuration Registers**

| MBAR offset | Name | Description |
|---|---|---|
| 0x0034 | SDRAM Chip Select 0 | Contains the Base Addresses and configurations for SDRAM's connected to the SDRAM controller. |
| 0x0038 | SDRAM Chip Select 1 | |

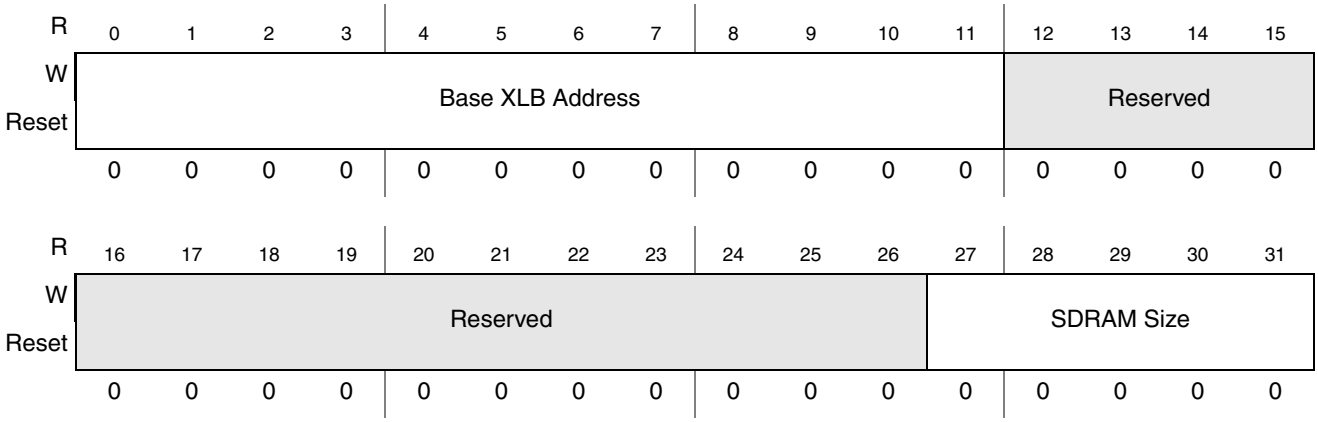



**Figure 3-3. SDRAM Chip Select Configuration Register**

**Table 3-6. SDRAM Chip Select Configuration Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:11 | Base XLB Address | Start address for memory |
| 12:26 | Reserved | These bits are reserved. |
| 27:31 | SDRAM size | Should be set to size of SDRAM at corresponding SDRAM chip select. Settings are included in the following table. |

**Note:** The Base XLB Address has to be SDRAM size aligned.

**Table 3-7. SDRAM Size Bit Settings**

| SDRAM Memory Size | SDRAM Size Bit Setting |
|---|---|
| 11111 | 4GB |
| 11110 | 2GB |
| 11101 | 1GB |
| 11100 | 512MB |
| 11011 | 256MB |
| 11010 | 128MB |
| 11001 | 64MB |
| 11000 | 32MB |
| 10111 | 16MB |
| 10110 | 8MB |
| 10101 | 4MB |
| 10100 | 2MB |
| 10011 | 1MB |
| 00001–10010 | Reserved |
| 0000 | Disable |

### 3.3.3.4 IPBI Control Register and Wait State Enable

The IPBI Control Register consists of the Enables for the Base Addresses set in Memory Map Space

Address MBAR + 0x0054

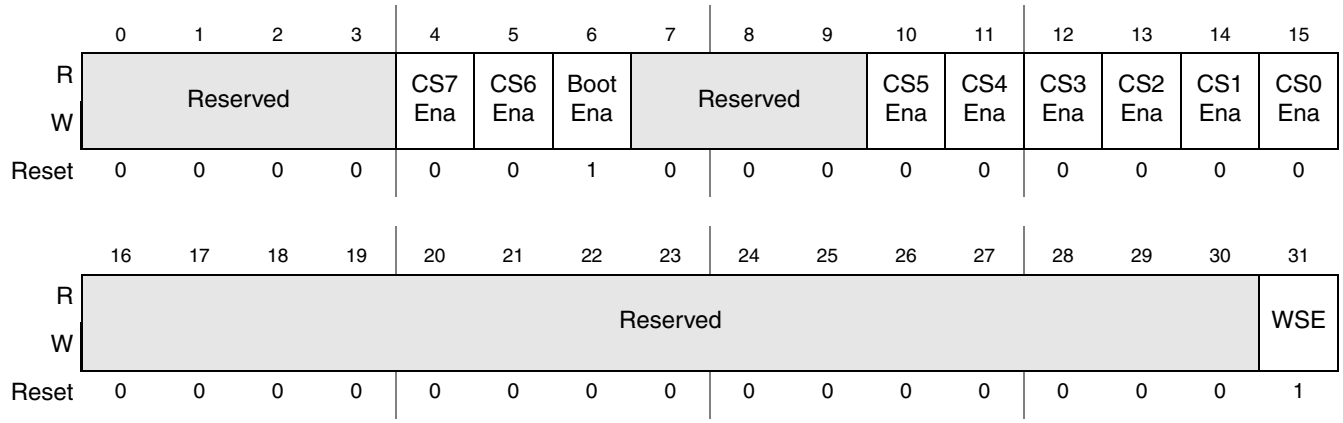



**Figure 3-4. IPBI Control Register**

**Table 3-8. IPBI Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | Reserved | These bits are reserved. |
| 4 | CS7 Ena | Chip Select 7 Enable |
| 5 | CS6 Ena | Chip Select 6 Enable |
| 6 | Boot Ena | Boot Enable |
| 7:9 | Reserved | These bits are reserved. |
| 10 | CS5 Ena | Chip Select 5 Enable |
| 11 | CS4 Ena | Chip Select 4 Enable |
| 12 | CS3 Ena | Chip Select 3 Enable |
| 13 | CS2 Ena | Chip Select 2 Enable |
| 14 | CS1 Ena | Chip Select 1 Enable |
| 15 | CS0 Ena | Chip Select 0 Enable |
| 16:30 | Reserved | These bits are reserved. |
| 31 | WSE | Wait State Enable bit. This bit should always be enabled when running an IP bus frequency of >66MHz. |

# Chapter 4
# Resets and Reset Configuration

## 4.1 Overview

The following sections are contained in this document:

- Hard and Soft Reset Pins
- Reset Sequence
- Reset Operation
- Other Resets
- Reset Configuration

## 4.2 Hard and Soft Reset Pins

MPC5200B has three primary reset pins, which are implemented as open drain I/Os[1]:

- Power-On Reset—$\overline{\text{PORRESET}}$
- Hard Reset—$\overline{\text{HRESET}}$
- Soft Reset—$\overline{\text{SRESET}}$

$\overline{\text{PORRESET}}$ is a power-on reset input. It is asserted by an external source and must be held active for a specified period of time until power is stable to the MPC5200B.

$\overline{\text{HRESET}}$ and $\overline{\text{SRESET}}$ can be asserted by an external source or they can be asserted by reset generation logic internal to MPC5200B.

Internal reset logic analyzes all internal and external reset sources and asserts internal and external reset signals appropriately.

When a hard reset ($\overline{\text{HRESET}}$) is detected, reset logic counters hold internal and external $\overline{\text{HRESET}}$ for a minimum of 4096 reference clock cycles or until the external $\overline{\text{HRESET}}$ source is released, whichever is longer.

1. All “open drain” outputs of MPC5200B are actually regular 3-state output drivers with the output data tied low, and the output enable controlled. Thus, unlike a true open drain, there is a current path from the external system to the MPC5200B I/O power rail if the external signal is driven above the MPC5200B I/O power rail voltage.

### 4.2.1 Power-On Reset—PORRESET

PORRESET must be asserted externally when power is applied to the system for a required period of time (see Section 4.4, "Reset Operation"). When PORRESET is asserted, internal logic forces HRESET and SRESET active. PORRESET must remain asserted until the MPC5200B system oscillator begins oscillation and the system APLL establishes a locked condition.

During PORRESET or HRESET the reset configuration word is sampled to establish the initial state of various vital internal MPC5200B functions. The reset configuration word is latched internally when HRESET is released.

When initiated by PORRESET, HRESET asserts and remains asserted for 4096 reference clocks after PORRESET is released.

Source of power-on reset is an external, board level reset source like a push button, reset control logic, etc.

### 4.2.2 Hard Reset—HRESET

HRESET is a bidirectional signal with a Schmitt-trigger input and an open drain output. HRESET requires an external pull-up. Assertion of external HRESET causes external HRESET and SRESET, and internal hard and soft resets, to be asserted for at least 4096 reference clock cycles.

During PORRESET or HRESET the reset configuration word is sampled to establish the initial state of various vital internal MPC5200B functions. The reset configuration word is latched internally when PORRESET or HRESET is released.

HRESET can also be asserted by internal sources. When HRESET is asserted internally, external HRESET and SRESET are also asserted.

Sources of hard reset are:

- PORRESET or HRESET pins asserted
- Hard reset asserted by debug module
- Reset signal asserted by watchdog timer or checkstop reset

### 4.2.3 Soft Reset—SRESET

External SRESET is an open drain signal. SRESET requires an external pull-up. Assertion of SRESET causes assertion of the internal soft reset. Internal soft reset is actually an *interrupt* that takes the same exception vector as HRESET. In particular, this means that SRESET cannot abort a hung XLB operation, and no device should use SRESET in a way that interferes with any bus operation in progress.

SRESET can also be asserted by internal sources. When SRESET is asserted internally, external SRESET is also asserted.

Sources of soft reset:

- PORRESET, HRESET, or SRESET external pins asserted
- Soft reset bit in Clock Distribution Module (CDM) register asserted by processor
- Soft reset asserted by debug module

## 4.3 Reset Sequence

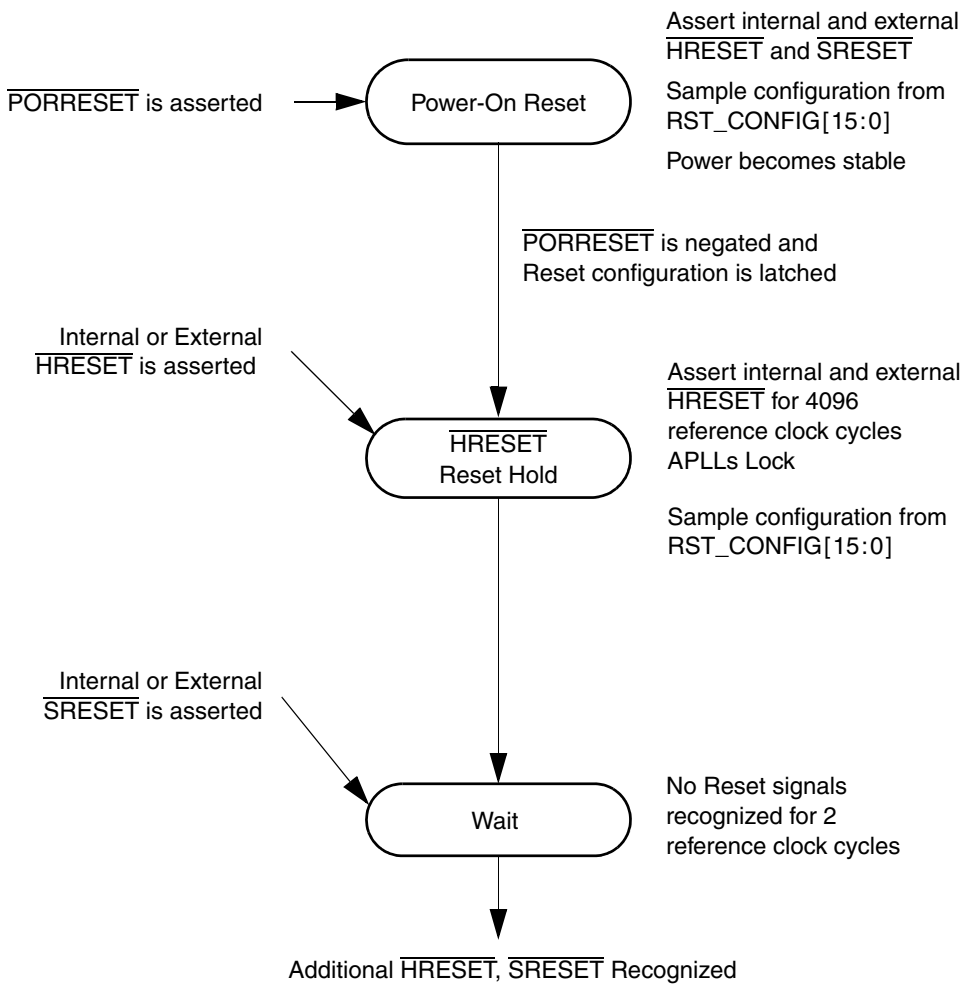

Assert internal and external HRESET and SRESET
PORRESET is asserted
Power-On Reset
Sample configuration from RST_CONFIG[15:0]
Power becomes stable
PORRESET is negated and Reset configuration is latched
Internal or External HRESET is asserted
Assert internal and external HRESET for 4096 reference clock cycles APLLs Lock
HRESET Reset Hold
Sample configuration from RST_CONFIG[15:0]
Internal or External SRESET is asserted
No Reset signals recognized for 2 reference clock cycles
Wait
Additional HRESET, SRESET Recognized

**Figure 4-1. Reset sequence**

## 4.4 Reset Operation

PORRESET must remain asserted for at least 100µs after all power supplies and the system oscillator input are stable and operating within specs. Following deassertion of power-on reset, HRESET and SRESET remain low for 4096 reference clock cycles.

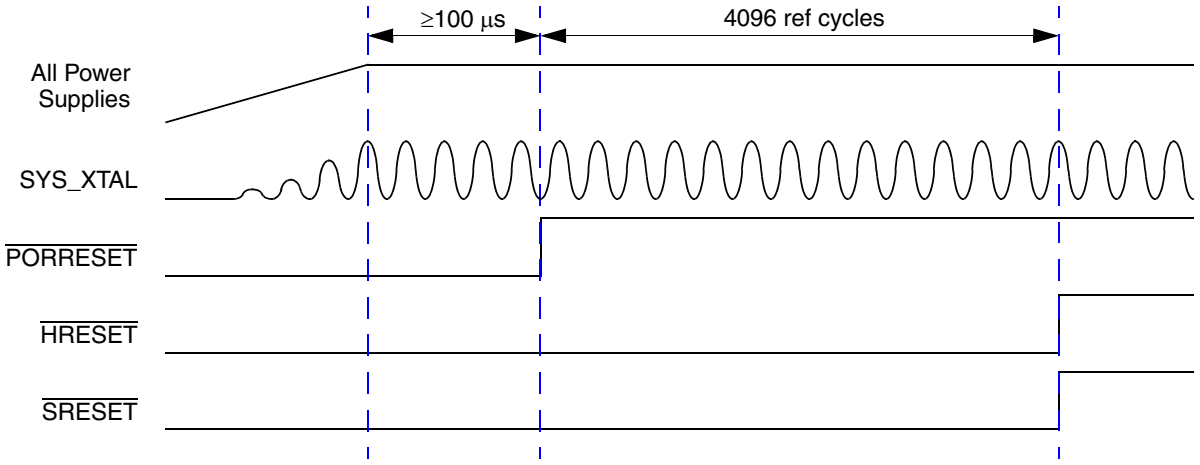



**Figure 4-2. PORRESET Assertion**

When external HRESET is asserted, internal reset logic catches the reset signal held low and asserts internal hard and soft resets for 4096 reference clock cycles. The external reset signal must be held low for at least 4 reference clock cycles (must catch 4 rising edges of reference clock) to be recognized and assert the internal reset signals.

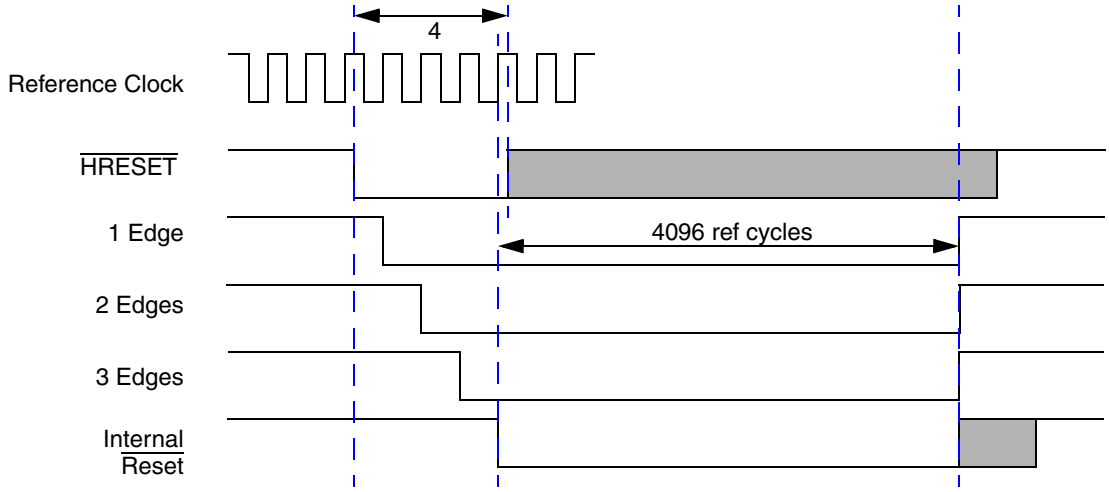



**Figure 4-3. Internal Hard Reset vs External HRESET Assertion**

The Clock Distribution Module contains a register that can be written by the microprocessor to assert soft reset. Writing the SRESET bit in this register to zero causes external SRESET and internal soft reset to be asserted.

## 4.5 Other Resets

MPC5200B has four other reset signals. These signals are specific to certain peripheral modules and are controlled in the context of that module, not globally.

**Table 4-1. Module Specific Reset Signals**

| | Definition |
|---|---|
| PCI_RESET | PCI bus reset output. Generated by processor write to a PCI register. |
| AC97_1_RES | AC97 reset output. Generated from the AC97 PSC1 module. |
| AC97_2_RES | AC97 reset output. Generated from the AC97 PSC2 module. |
| JTAG_TRST | JTAG reset input. Generated externally from JTAG or debug control logic. This input only resets the JTAG logic. Other system resets ($\overline{\text{PORRESET}}$, $\overline{\text{HRESET}}$, and $\overline{\text{SRESET}}$) do not reset the JTAG logic.<br>**Note:** For information on the reset signal JTAG_TRST and the relationship to other reset signals refer to the MPC5200 Hardware Specifications. |
| ATA Reset | This is NOT a reset pin on MPC5200B. The ATA reset for the external drive must be supplied by the board level reset source, or if software control is required, generated via a GPIO. |

## 4.6 Reset Configuration

The MPC5200B is initialized by sampling values found on specific device pins during power-on reset ($\overline{\text{PORRESET}}$) or hard-reset ($\overline{\text{HRESET}}$). These pins are outputs in normal operation, but are sampled as inputs during power-on reset or hard-reset. External pull-up or pull-down resistors on the board are used to force a value on these pins during power-on reset or hard-reset. These values are latched into the CDM Reset Configuration register at the end of power-on reset or hard-reset, then distributed to various peripherals. After power-on reset or hard-reset, these outputs overdrive the external pull-up or pull-down resistors and behave as functional outputs. Only during power-on reset or hard-reset these pins are inputs.

Table 4-2 gives the power-on reset or hard-reset configuration inputs.

**Table 4-2. Reset Configuration Word Source Pins**

| Pkg Ball | Reset Config Pin | I/O Signal Name | CDM Reset Config Register Bit | Config Signal from CDM | Description |
|---|---|---|---|---|---|
| Y18 | RST_CFG0 | ATA_DACK | PORCFG[31] | ppc_pll_cfg_4 | MPC5200B G2_LE PPC Core PLL Configuration |
| Y17 | RST_CFG1 | ATA_IOR | PORCFG[30] | ppc_pll_cfg_3 | |
| W17 | RST_CFG2 | ATA_IOW | PORCFG[29] | ppc_pll_cfg_2 | |
| W16 | RST_CFG3 | LP_RWB | PORCFG[28] | ppc_pll_cfg_1 | |
| V14 | RST_CFG4 | LP_ALE | PORCFG[27] | ppc_pll_cfg_0 | |
| Y13 | RST_CFG5 | LP_TS | PORCFG[26] | xlb_clk_sel | bit=0:XLB_CLK=$f_{system}$ / 4<br>bit=1:XLB_CLK=$f_{system}$ / 8 |
| H02 | RST_CFG6 | USB1_1 | PORCFG[25] | sys_pll_cfg_0 | bit=0:$f_{system}$=16 x SYS_XTAL_IN<br>bit=1:$f_{system}$=12 x SYS_XTAL_IN |
| H03 | RST_CFG7 | USB1_2 | PORCFG[24] | sys_pll_cfg1 | bit=0:$f_{vcosys}$ = $f_{system}$<br>bit=1:$f_{vcosys}$ = 2 x $f_{system}$ |

**Table 4-2. Reset Configuration Word Source Pins (continued)**

| Pkg Ball | Reset Config Pin | I/O Signal Name | CDM Reset Config Register Bit | Config Signal from CDM | Description |
|---|---|---|---|---|---|
| K01 | RST_CFG8 | ETH0 | PORCFG[23] | boot_rom_mg | bit=0:No Boot in Most Graphics Mode [1]<br>bit=1:Boot in Most Graphics Mode [1,2,4] |
| K03 | RST_CFG10 | ETH2 | PORCFG[21] | ppc_msrip | Microprocessor Boot Address/Exception table location.<br>bit=0:0000_0100 (hex)<br>bit=1:FFF0_0100 (hex) |
| J01 | RST_CFG11 | ETH3 | PORCFG[20] | boot_rom_wait | bit=0:4 PCI bus clocks of wait state<br>bit=1:48 PCI bus clocks of wait state |
| J02 | RST_CFG12 | ETH4 | PORCFG[19] | boot_rom_swap | bit=0:no byte lane swap, same endian ROM image<br>bit=1:byte lane swap, different endian ROM image |
| L03 | RST_CFG13 | ETH5 | PORCFG[18] | boot_rom_size | For non-muxed boot ROMs: [2,3]<br>bit=0:8bit boot ROM data bus, 24bit max boot ROM address bus<br>bit=1:16bit boot ROM data bus, 16bit boot ROM address bus<br>For muxed boot ROMs:<br>boot ROM address is max 25 significant bits during address tenure.<br>bit=0:16bit ROM data bus<br>bit=1:32bit ROM data bus |
| N02 | RST_CFG14 | ETH6 | PORCFG[17] | boot_rom_type | bit=0:non-muxed boot ROM bus, single tenure transfer. [1]<br>bit=1:muxed boot ROM bus, with address and data tenures, $\overline{\text{ALE}}$ and $\overline{\text{TS}}$ active. [1] |
| K02 | RST_CFG15 | ETH1 | PORCFG[16] | large_flash_sel | bit=0:No Boot in Large Flash Mode [1]<br>bit=1:Boot in Large Flash Mode [1,3,4] |

**Note:**

1. If multiple settings are chosen, the following priorities are valid:
   large_flash_sel
   boot_rom_mg
   boot_rom_type
2. The boot_rom_size configuration signal doesn't influence the address and data bus width of the MOST Graphics boot mode configuration. The maximum address bus width is fixed to 24 bit and the data bus width is fixed to 32 bit.
3. The boot_rom_size configuration signal doesn't influence the address bus width of the Large Flash boot mode configuration. The maximum address bus width is fixed to 26 bit.
4. The PCI controller is disabled, if booting in Large Flash or MOST Graphics mode is selected.

# Chapter 5
# Clocks and Power Management

## 5.1 Overview

The following sections are contained in this document:

- Clock Distribution Module (CDM)
- MPC5200B Clock Domains
- Power Management
- CDM Registers

## 5.2 Clock Distribution Module (CDM)

The CDM is the source of all internally generated clocks and reset signals. The MPC5200B clock generation uses two analog phase locked loop (APLL) blocks. The system APLL takes an external reference frequency (nominal 27–33MHz) and generates the following internal clocks. See Table 5-1.

**Table 5-1. Clock Distribution Module**

| Clock Name | Description |
|---|---|
| XLB CLOCK (xlb_clk) | Microprocessor on-chip 64-bit XLB clock. This is the fundamental MPC5200B frequency. |
| MEM_CLOCK (mem_clock) | SDRAM Controller memory clock supplied to external SDRAM devices. Max frequency is 132MHz. The memory clock frequency is always equal to the XLB frequency. |
| IPB CLock (ipb_clk) | Intellectual Property Bus (IPB) clock. |
| PCI CLOCK (pci_clk) | PCI Controller clock. |
| CORE CLOCK | Clock for the e300 Core. The core APLL takes the XLB clock and generates the e300 clock. |
| 48MHz CLOCK USB CLOCK | 48MHz clock for USB and IrDA (PSC6). This clock can be sourced internally from the CDM or from an external source via the IrDA_USB_CLK pin. |

## 5.3 MPC5200B Clock Domains

The MPC5200B has 5 major clock domains, which are listed below. Details are given in the sections that follow.

- e300 Core Clock Domain—internal processor core frequency
- Processor Bus (XLB) Clock Domain —internal e300 Core processor bus
- SDRAM Memory Controller Clock Domain
- IPB Clock Domain—programming register and peripheral interface frequency
- PCI Clock Domain

The following smaller peripheral clock domains can be asynchronous to the fundamental clock frequencies on MPC5200B:

- **Ethernet**—The Ethernet Controller requires a 10MHz (10 Mbit operation) or 25MHz (100 Mbit operation) Tx/Rx clock. Both clocks are inputs to the MPC5200B, supplied from the Ethernet physical device (ETH_RXCLK, ETH_TXCLK pins). The Ethernet Controller Tx/Rx portion of the MPC5200B is asynchronous to the rest of MPC5200B.
- **USB**—The Universal Serial Bus module Tx/Rx portion can be clocked by an external clock source (IR_USB_CLK pin) or by an internally generated clock. Clock frequency must be 48MHz. When the clock source is externally supplied, the USB module Tx/Rx portion is asynchronous to the rest of MPC5200B.
- **PSC**—The PSC (Programmable Serial Controller) module is instantiated in the MPC5200B 6 times (PSC1 to PSC6). The PSC has different modes of operation. In some cases the logic is clocked by internally generated clocks (i.e., UART mode), and in others the PSC is clocked by external clock sources (i.e., CODEC mode). If the PSC logic is clocked from an external source then the logic is asynchronous to the rest of the chip.
- When the PSC6 is configured as **IrDA**—The Infrared Data Association module Tx/Rx portion can be clocked by an external clock source (IR_USB_CLK pin) or by an internally generated clock.
  - — When generated internally, the clock source can be a fix 48MHz clock generator or a programmable clock generator (Mclk).
  - — When generated externally, the frequency can be different

**NOTE**

Only one pin is allocated to supply the USB and PSC6/IrDA clock. If both modules require external clock generation, the frequency must be 48MHz.

- **SPI**—The SPI (Serial Peripheral Interface) has a clock input pin, SPI_CLK. When the SPI is configured as a slave, the clock is supplied externally. The SPI module therefore has a small asynchronous clock domain.
- **$I^2C$**—There are two $I^2C$ (Inter-Integrated Circuit) modules on MPC5200B. Both have input source clocks ($I^2Cx$_CLK) and therefore asynchronous clock domains.
- **RTC**—The RTC (Real-Time Clock) has its own clock domain, clocked by an external 32.768KHz oscillator. The two oscillator pins are RTC_XTAL_IN and RTC_XTAL_OUT. There is an asynchronous boundary between this clock domain and the IPB register interface.

- **JTAG**—The JTAG (Joint Test Action Group) has its own clock domain clocked by the JTAG_TCK pin.

The following peripheral functions use clocks generated from CDM.

- **MSCAN**—The MSCAN (Freescale [formerly Motorola] Scalable Controller Area Network) internal baud rate generator also uses the ipb_clk or can be derived from the oscillator clock sys_xtal_in. The resultant divided clock samples an incoming CAN data stream and generates an outgoing data stream.

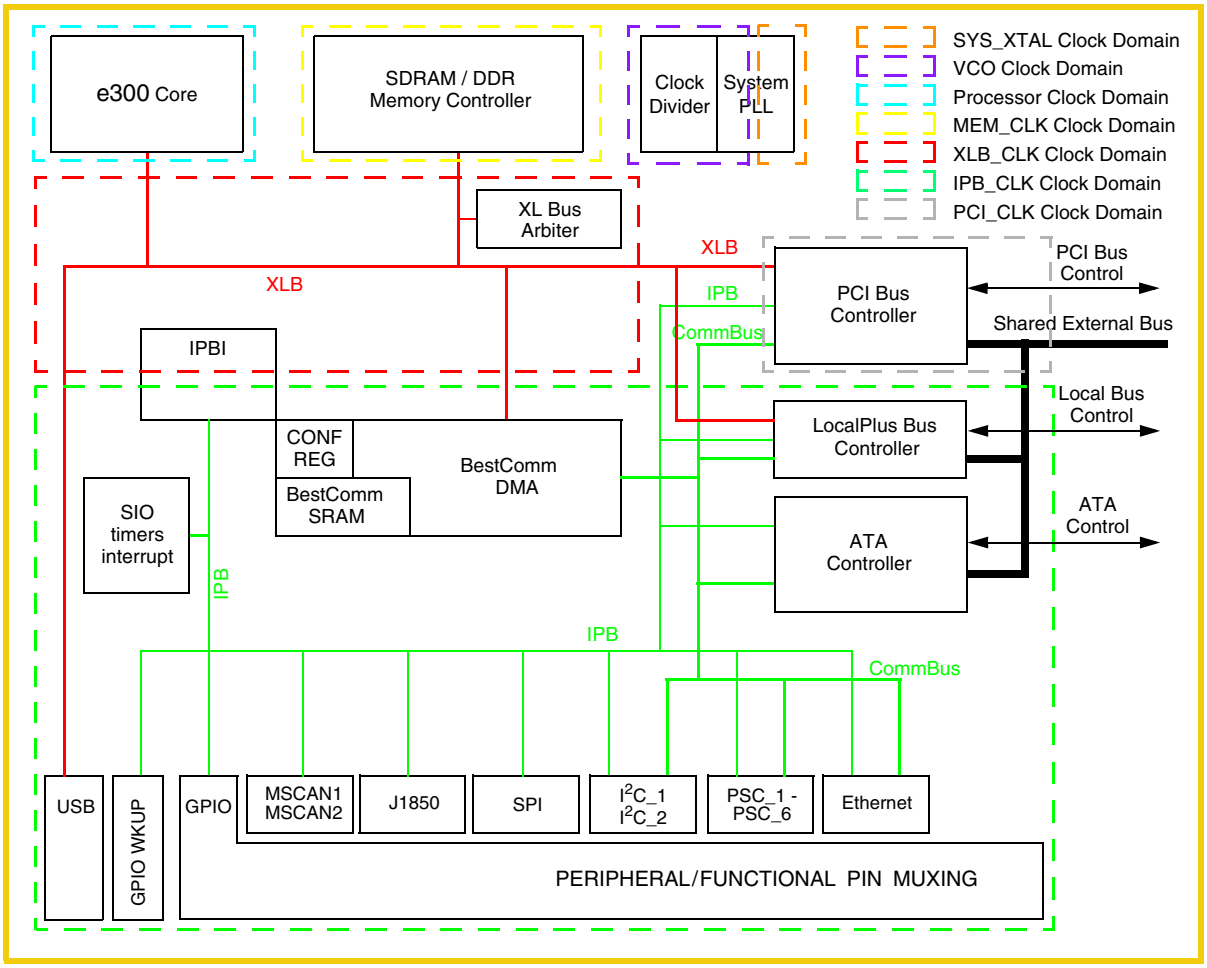



**Figure 5-1. Primary Synchronous Clock Domains**

### 5.3.1 MPC5200B Top Level Clock Relations

Figure 5-2 shows the CDM clock divide circuitry. This picture shows only the functional clocks. The clock network regarding the scan and bypass modes is not included.

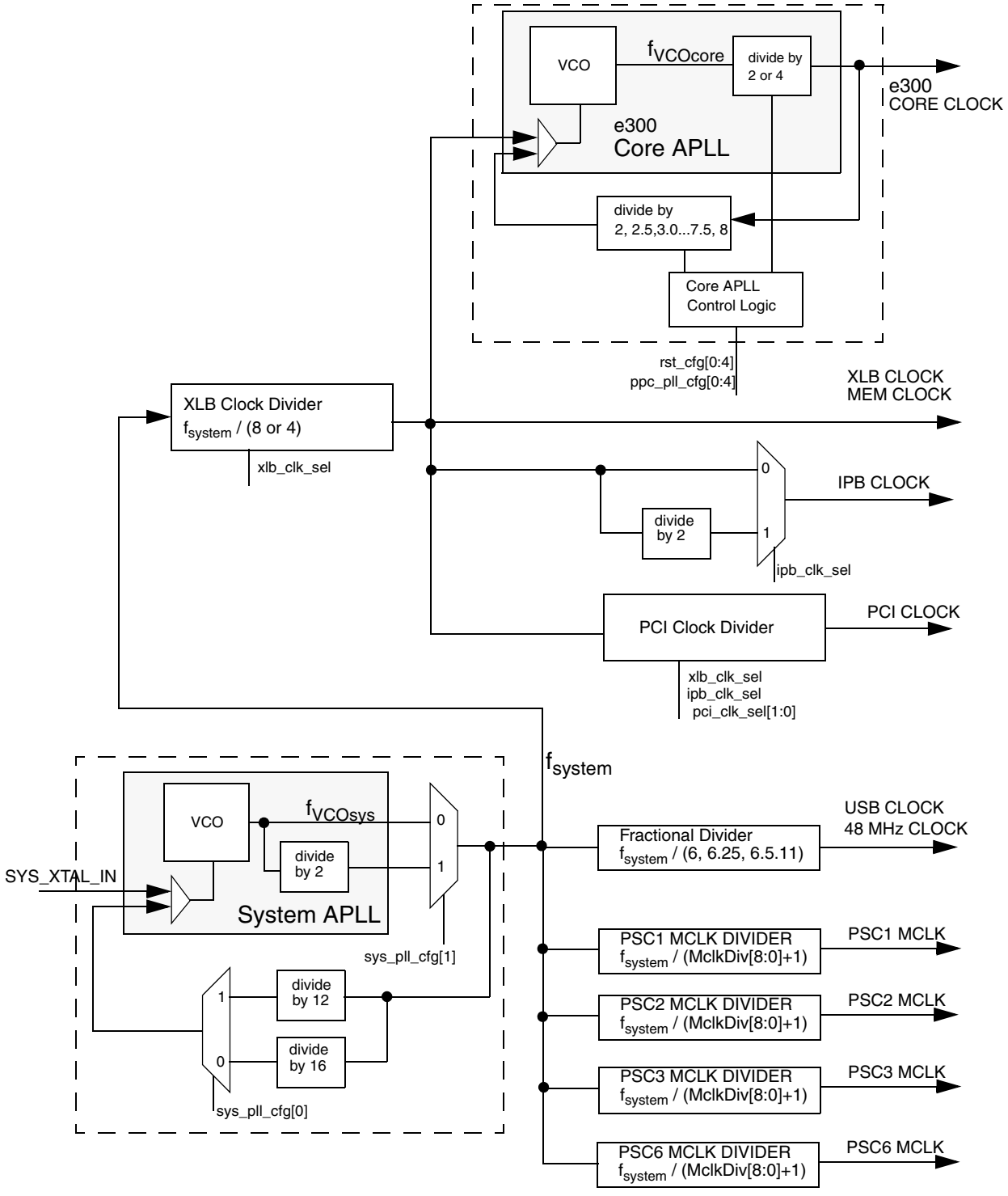



**Figure 5-2. MPC5200 Clock Relations**

Table 5-2 shows the System PLL configuration and the corresponding fsystem frequencies for a 27.0 MHz and 33.0 MHz input clock. Table 5-3 shows all possible clock ratios.

**Table 5-2. System PLL Ratios**

| SYS_XTAL_IN | sys_pll_cfg[1] | sys_pll_cfg[0] | $f_{VCOsys}$ [MHz] | $f_{system}$ [MHz] |
|---|---|---|---|---|
| 27.0 | 0 | 0 | 432.0 | 432.0 |
| | 0 | 1 | 324.0 | 324.0 |
| | 1[1] | 0 | 864.0 | 432.0 |
| | 1 | 1 | 648.0 | 324.0 |
| 33.0 | 0 | 0 | 528.0 | 528.0 |
| | 0 | 1 | 396.0 | 396.0 |
| | 1[1] | 0 | 1056.0 | 528.0 |
| | 1 | 1 | 792.0 | 396.0 |

[1] These are invalid configurations. The $f_{VCOsys}$ frequencies exceed the maximum operation frequency. See MPC5200B Hardware Specification.

**Table 5-3. MPC5200B Clock Ratios**

| xlb_clk_sel | XLB CLOCK | ipb_clk_sel | IPB CLOCK | pci_clk_sel[1:0] | PCI CLOCK | CLOCK Ratio XLB:IPB:PCI |
|---|---|---|---|---|---|---|
| 0 | $f_{system}$ / 4 | 0 | XLB | 00 | XLB | 4:4:4 |
| 0 | $f_{system}$ / 4 | 0 | XLB | 01 | XLB/2 | 4:4:2 |
| 0 | $f_{system}$ / 4 | 0 | XLB | 10 | XLB/4 | 4:4:1 |
| 0 | $f_{system}$ / 4 | 0 | XLB | 11 | XLB/4 | 4:4:1 |
| 0 | $f_{system}$ / 4 | 1 | XLB /2 | 00 | XLB/2 | 4:2:2 |
| 0 | $f_{system}$ / 4 | 1 | XLB /2 | 01 | XLB/4 | 4:2:1 |
| 0 | $f_{system}$ / 4 | 1 | XLB /2 | 10 | XLB/4 | 4:2:1 |
| 0 | $f_{system}$ / 4 | 1 | XLB /2 | 11 | XLB/4 | 4:2:1 |
| 1 | $f_{system}$ / 8 | 0 | XLB | 00 | XLB | 2:2:2 |
| 1 | $f_{system}$ / 8 | 0 | XLB | 01 | XLB/2 | 2:2:1 |
| 1 | $f_{system}$ / 8 | 0 | XLB | 10 | XLB/4 | 2:2:0.5 |
| 1 | $f_{system}$ / 8 | 0 | XLB | 11 | XLB/4 | 2:2:0.5 |
| 1 | $f_{system}$ / 8 | 1 | XLB /2 | 00 | XLB/2 | 2:1:1 |
| 1 | $f_{system}$ / 8 | 1 | XLB /2 | 01 | XLB/4 | 2:1:0.5 |
| 1 | $f_{system}$ / 8 | 1 | XLB /2 | 10 | XLB/4 | 2:1:0.5 |
| 1 | $f_{system}$ / 8 | 1 | XLB /2 | 11 | XLB/4 | 2:1:0.5 |

**Table 5-4. Typical System Clock Frequencies**

| $f_{system}$ [MHz] | XLB Clock [MHz] | IPB CLock [MHz] | PCI CLOCK [MHz] | Clock Ratio XLB:IPB:PCI |
|---|---|---|---|---|
| 528.0 | 132.0 | 132.0 | 66.0 | 4:4:2 |
| | | | 33.0 | 4:4:1 |
| | | 66.0 | 66.0 | 4:2:2 |
| | | | 33.0 | 4:2:1 |
| | | 33.0 | 33.0 | 4:1:1 |
| | 66.0 | 66.0 | 66.0 | 2:2:2 |
| | | | 33.0 | 2:2:1 |
| | | 33.0 | 33.0 | 2:1:1 |

Table 5-4 shows the typical clock ratios with a 33.0 MHz clock input on the SYS_XTAL_IN pin and a System PLL divide value 16 (sys_pll_cfg[0] = 0).

**NOTE**

Frequency ranges in Table 5-3 and Table 5-4 represent possible ranges of operation. A variety of conditions may prevent the part from actually performing at these frequency ranges. For data relating to actual performance, see Section A.2, AC Timing.

### 5.3.2 e300 Core Clock Domain

The e300 Core has its own APLL and clock domain, which is separate from, but synchronous with, the rest of the chip. The reference for the processor APLL is the XLB clock. The e300 Core can run at all integer and half-integer multiples of xlb_clk from 2x to 8x (i.e., 2x, 2.5x, 3x, 3.5x, 4x, 4.5x, 5x, 5.5x, 6x, 6.5x, 7x, 7.5x, 8x) to a maximum frequency of 396MHz. Table 5-5 shows the available core frequencies based on the xlb_clk frequency range.

**NOTE**

These frequencies are not guaranteed. Actual operation frequencies will depend on silicon characterization and operating conditions.

**Table 5-5. e300 Core Frequencies vs. XLB Frequencies**

| XLB Clock (MHz) | | 132 | 108 | 99 | 81 | 66 | 54 | 49.5 | 40.5 | 33 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| e300 Core PLL Bus to Core Multiplier[1] | x1 | — | — | — | — | — | — | — | — | — | — |
| | x1.5 | — | — | — | — | — | — | — | — | — | — |
| | x2 | 264 | 216 | 198 | 162 | 132 | 108 | 99 | 81 | 66 | 54 |
| | x2.5 | 330 | 270 | 247.5 | 202.5 | 165 | 135 | 123.8 | 101.3 | 82.5 | 67.5 |
| | x3 | 396 | 324 | 297 | 243 | 198 | 162 | 148.4 | 121.5 | 99 | 81 |
| | x3.5 | | 378 | 346.5 | 283.5 | 231 | 189 | 173.3 | 141.8 | 115.5 | 94.5 |
| | x4 | | | 396 | 324 | 264 | 216 | 198 | 162 | 132 | 108 |
| | x4.5 | | | | 364.5 | 297 | 243 | 222.8 | 182.3 | 148.5 | 121.5 |
| | x5 | | | | | 330 | 270 | 247.5 | 202.5 | 165 | 135 |
| | x5.5 | | | | | 363 | 297 | 272.3 | 222.8 | 181.5 | 148.5 |
| | x6 | | | | | 396 | 324 | 297 | 243 | 198 | 162 |
| | x6.5 | | | | | | 351 | 321.8 | 263.3 | 214.5 | 175.5 |
| | x7 | | | | | | 378 | 346.5 | 283.5 | 231 | 189 |
| | x7.5 | | | | | | | 371.3 | 303.8 | 247.5 | 202.5 |
| | x8 | | | | | | | 396 | 324 | 264 | 216 |

**Note:** 1x and 1.5x multiply ratios are not available in this version of the MPC5200B.

[1] See Table 5-6, XLB to CORE clock ratio.

Table 5-6 gives the e300 Core APLL and operating frequency options compared to the xlb_clk reference input (shown in Figure 5-2). The selection of an e300 Core frequency is made at Power-On Reset (POR) via the reset configuration inputs. For more information see Section 4.6, “Reset Configuration”.

Frequency ranges indicated in Table 5-6 represent possible ranges for the processor APLL. A variety of conditions may prevent the part from actually performing at these frequency ranges. For data relating to actual performance, see the MPC5200B Hardware Specification.

**Table 5-6. e300 Core APLL Configuration Options**

| ppc_pll_cfg | | Bus:Core Ratio (XLB : CORE CLOCK) | Core:VCO Ratio (CORE CLOCK: $f_{VCOcore}$) | Bus:VCO Ratio (XLB : $f_{VCOcore}$) |
|---|---|---|---|---|
| hex | [0:1:2:3:4] | | | |
| 0x00 | 00000 | — | — | — |
| 0x01 | 00001 | — | — | — |
| 0x02 | 00010 | — | — | — |
| 0x04 | 00100 | 1:2 | 1:2 | 1:4 |
| 0x05 | 00101 | 1:2 | 1:4 | 1:8 |
| 0x06 | 00110 | 1:2.5 | 1:2 | 1:5 |
| 0x07 | 00111 | 1:4.5 | 1:2 | 1:9 |
| 0x08 | 01000 | 1:3 | 1:2 | 1:6 |
| 0x09 | 01001 | 1:5.5 | 1:2 | 1:11 |
| 0x0A | 01010 | 1:4 | 1:2 | 1:8 |
| 0x0B | 01011 | 1:5 | 1:2 | 1:10 |
| 0x0C | 01100 | — | — | — |
| 0x0D | 01101 | 1:6 | 1:2 | 1:12 |
| 0x0E | 01110 | 1:3.5 | 1:2 | 1:7 |
| 0x10 | 10000 | 1:3 | 1:4 | 1:12 |
| 0x11 | 10001 | 1:2.5 | 1:4 | 1:10 |
| 0x12 | 10010 | 1:6.5 | 1:2 | 1:13 |
| 0x14 | 10100 | 1:7 | 1:2 | 1:14 |
| 0x16 | 10110 | 1:7.5 | 1:2 | 1:15 |
| 0x18 | 11000 | — | — | — |
| 0x1C | 11100 | 1:8 | 1:2 | 1:16 |
| 0x03<br>0x13 | 00011<br>10011 | PLL off/bypassed<br>xlb_clk clocks core directly, 1x bus-to-core | | |
| 0x0F<br>0x1F | 01111<br>11111 | PLL off, no core clocking occurs. | | |
| 0x15<br>0x17<br>0x19<br>0x1A<br>0x1B<br>0x1D<br>0x1E | 10101<br>10111<br>11001<br>11010<br>11011<br>11101<br>11110 | Reserved, should not be used. | | |

**Note:** Shading implies same mode can be configured with ppc_pll_cfg[0]=0

## NOTE

The XLB CLOCK frequency and the ppc_pll_cfg[0:4] must be chosen such that resulting CORE CLOCK frequency and PLL ($f_{VCOcore}$) frequency do not exceed their respective maximum or minimum operating frequencies. Refer to Table 5-5 and MPC5200B Hardware Specification.

### 5.3.3 Processor Bus (XLB) Clock Domain

The XLB clock (xlb_clk) is the fundamental MPC5200B clock frequency. The following operate at this frequency:

- The internal processor address/data bus
- The internal SDRAM Controller
- External SDRAM

All functional blocks that interface to the XLB must operate at this frequency, or have a section of logic that operates at this frequency.

### 5.3.4 SDRAM Memory Controller Clock Domain

The Memory Controller uses the clocks shown in Table 5-7.

**Table 5-7. SDRAM Memory Controller Clock Domain**

| Bits | Description |
|---|---|
| mem_clk | mem_clk is always the same frequency as xlb_clk. |
| mem_2x_clk, $\overline{\text{mem\_2x\_clk}}$ | These internal clocks are twice the frequency of xlb_clk and are used to add more resolution to SDRAMC control signals |
| mem2x1x_clk (becomes mem_rd_clk) | This is the source of the internal memory read clock. It always operates at the memory data rate, 1x mem_clk for SDR, 2x mem_clk for DDR. The physical circuit path of mem2x1x_clk is matched as closely as possible to the on-chip portion of the memory clock output and the read data input; a tapped delay chain is used to match off-chip portions of the memory clock and read data path. |

Figure 5-3 shows the clock relationships for the SDRAM Controller.

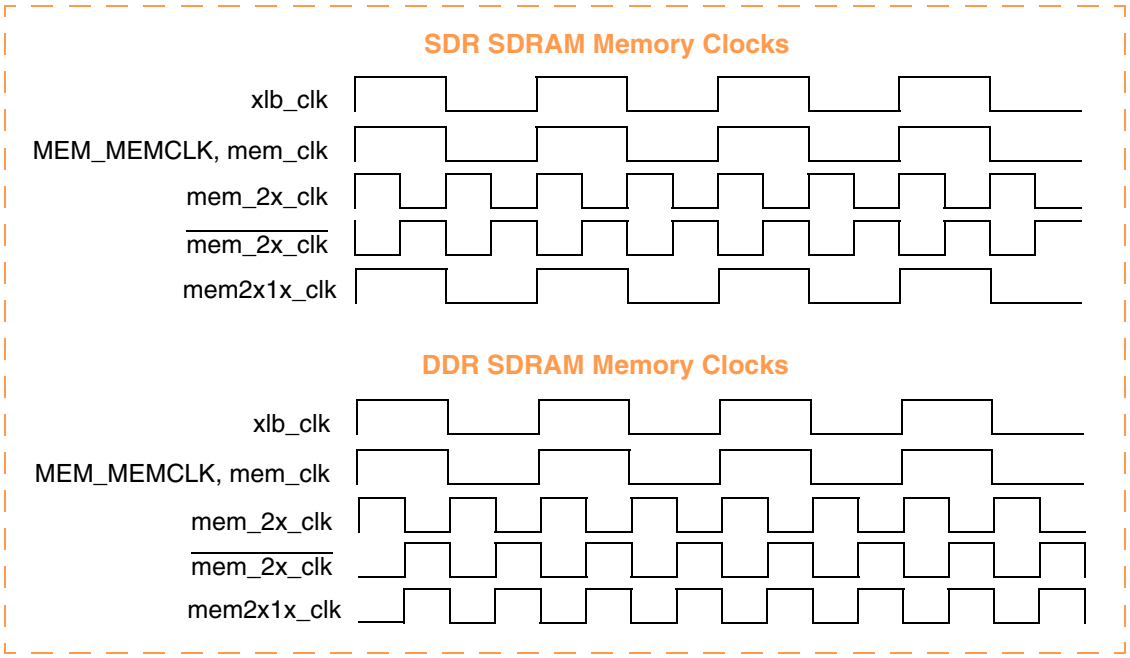



**Figure 5-3. Timing Diagram—Clock Waveforms for SDRAM and DDR Memories**

The XLB is 64bits and the SDRAM external bus is 32bits. When SDR (single data rate) SDRAM memory is used, the XLB bandwidth is only half utilized. When DDR (dual data rate) memory is used, the XLB bandwidth is fully used on SDRAM transactions.

MPC5200B supplies 2 external memory clocks as part of the SDRAM interface:

- MEM_MEMCLK
- MEM_MEMCLK

MEM_MEMCLK and $\overline{\text{MEM\_MEMCLK}}$ are always the same frequency as XLB clock. SDR memory uses MEM_MEMCLK only; DDR memory uses both MEM_MEMCLK and $\overline{\text{MEM\_MEMCLK}}$.

### 5.3.5 IPB Clock Domain

IPB clock can run at the same frequency as XLB clock, or 1/2 the frequency. BestComm runs at the IPB clock frequency as does all IPB control register access logic.

### 5.3.6 PCI Clock Domain

The PCI bus clock is the fundamental frequency of the PCI bus interface. The PCI clock can run at the XLB clock frequency, or 1/2 the XLB clock frequency, or 1/4 the XLB clock frequency. The PCI clock cannot be faster than IPB Clock.

## 5.4 Power Management

Power Management modes are listed below. Details are given in the sections that follow.

- Full-Power Mode
- Power Conservation Modes

The MPC5200B design is equipped with many power conservation features, which are supported in the peripherals and system logic. The e300 Core has its own power-down modes:

- nap
- doze
- sleep

Individual peripheral functions can be disabled by stopping the module's clock. In addition to clock control of individual peripheral functions, clock control sequencer (CCS) logic sequences the MPC5200B clock system to enter and exit a deep-sleep power mode. This limits power consumption to device leakage levels.

The MPC5200B system is driven by:

- a 27/33MHz system OSC, and
- a 32KHz real-time clock (RTC) OSC.

The 27/33MHz OSC drives the main clock system through a PLL that multiplies the frequency for the system buses and peripherals on the chip. The e300 Core uses the XLB frequency as an input to the microprocessor PLL that generates the internal core frequencies.

The RTC clock domain is completely separate from the 27/33MHz clock domain. All interactions between the RTC clock domain and any other are handled with synchronizers.

### 5.4.1 Full-Power Mode

In Full-Power mode both the system PLL and microprocessor PLL are locked and the main system clocks are supplied to the MPC5200B system. In this mode, the e300 Core may use the Dynamic Power Mode (DPM). If this mode is enabled, logic not required for instruction execution, is not activated. This results in power reduction over a design that would be fully clocked during normal operation.

Performance in not decreased in Dynamic Power Mode, so it is recommended that it should never be disabled (although it is possible) when running the core at full speed.

MPC5200B peripherals can be individually enabled based on what functionality is required by the application running and the external stimulus presented to MPC5200B. Peripherals not required can be powered-down through a write to an MPC5200B system control register which disables the peripheral and gates the peripheral clock.

### 5.4.2 Power Conservation Modes

Sleep modes in the MPC5200B design can be exercised through microprocessor sleep mode control and peripheral clock disables. In all modes except Deep-Sleep mode, the system crystal oscillator is enabled, and the system PLL and microprocessor PLL remain locked. Response time to WakeUP interrupts is faster than in the deep-sleep mode (see Section 5.4.4, “Deep-Sleep Mode”). Since clocks are still running in the MPC5200B chip, any interrupt normally present in the MPC5200B design can be used to wake up the power-down logic. See Section 5.5.1.6, “CDM Clock Enable Register”, Clock Enable register.

### 5.4.3 e300 Core Power Modes

The e300 Core power management modes are listed below. Details are given in the sections that follow.

- Dynamic Power Mode (default power state)
- Doze Mode
- Nap Mode
- Sleep Mode

These modes are controlled by writes to an internal e300 Core control register. These modes only apply to the e300 Core. Logic outside the e300 Core remains active unless separately disabled. In any of these modes, peripherals can be enabled or disabled by writing to an MPC5200B system control register.

#### 5.4.3.1 Dynamic Power Mode

This is the default power state mode. The core is fully powered and internal functional units are operating at the full processor clock speed. If Dynamic Mode is enabled, idle functional units automatically enter a low-power state. This does not effect:

- Performance
- Software execution
- External hardware

#### 5.4.3.2 Doze Mode

All functional e300 Core units are disabled except for the time base/decrementer registers and the bus snooping logic. When the processor is in Doze Mode, any of the following actions returns the core to Full-Power Mode:

- An external asynchronous interrupt
- A system management interrupt
- A decrementer (DEC) exception
- A hard or soft reset
- A machine check input (MCP) signal

In Doze Mode, the core maintains the PLL in a fully powered state and locked to the system XLB clock input. Transition to Full-Power Mod takes only a few processor clock cycles.

#### 5.4.3.3 Nap Mode

The Nap Mode further reduces e300 Core power consumption by disabling bus snooping, leaving only the time base register and the PLL in a powered state. When in Nap Mode, any of the following actions returns the core to Full-Power Mod:

- An external asynchronous interrupt
- A system management interrupt
- A DEC exception
- A hard or soft reset
- An MCP signal

Transition to Full-Power Mode takes only a few processor clock cycles.

**NOTE**

It is not allowed to set the ccs_sleep_en bit of CDM Clock Control Sequencer Configuration Register before entering the nap mode. Otherwise all clocks will be disabled by entering the nap mode.

#### 5.4.3.4 Sleep Mode

Sleep Mode reduces e300 Core power consumption to a minimum. It does this by disabling all internal functional units.

Any of the following actions returns the core to Full-Power Mode:

- An external asynchronous interrupt
- A system management interrupt
- A hard or soft reset
- An MCP signal

In Sleep Mode it is possible to disable the e300 Core PLL, further reducing power. this requires special sequencing logic external to the e300 Core and is discussed in Section 5.4.4, “Deep-Sleep Mode”.

### 5.4.4 Deep-Sleep Mode

The MPC5200B system provides a very low power consumption mode where the 27/33MHz system oscillator, system PLL and e300 Core PLL are shut down and disabled. Once MPC5200B is sequenced into this mode and clocks are static, the current draw of the device (except the RTC) is reduced to leakage levels. The internal state of the device is maintained in Deep Sleep as long as power is maintained.

The real-time clock (RTC) is not disabled in Deep Sleep. If the RTC is used, that portion of the chip still consumes power in Deep Sleep.

Exiting Deep Sleep mode is initiated in one of the following ways:

- An interrupt from the RTC logic
- An external asynchronous interrupt (wake up interrupt)
- An interrupt from one of the MSCAN modules (which occurs when a data transition occurs on the serial input).

The RTC clock is necessary to wake up MPC5200B using an RTC interrupt. However, no clock is required to trigger the wake up process in the case of an external interrupt or the MSCAN module interrupt. This means the RTC clock does not have to be present to use Deep Sleep mode. The e300 Core must enable the deep sleep process in the CDM module, then put itself into sleep mode before the e300 Core PLL can be disabled.

Since MPC5200B clocks are stopped in Deep Sleep mode, the wake-up time is longer than in the e300 Core-only power down modes. A power-on sequence must occur which re-locks both the MPC5200B system and processor PLLs.

The sequence of events to enter and exit Deep Sleep mode are initiated by the e300 Core under software control and then sequenced in hardware by the Clock Control Sequencer (CCS) in CDM.

#### 5.4.4.1 Entering Deep Sleep

When entering Deep Sleep mode, the following occurs:

- e300 Core prepares the system for Deep Sleep power down.
  This could involve disabling peripheral interfaces, waiting for transmit/receive messages to complete, putting the SDRAM into self refresh mode, etc.
- e300 Core finishes instructions in the execution pipeline.
- e300 Core software enables the Deep Sleep mode with a write to a MPC5200B control register.
- e300 Core Processor software writes sleep mode configuration to e300 Core Processor control register.
- e300 Core Processor asserts the QREQ signal indicating that it would like to enter sleep mode.
- CCS waits for e300 Core Processor sleep (initiated by QREQ, since QACK is always asserted in MPC5200B).
- CCS disables interrupts.
- CCS waits for the e300 Core Processor to enter the sleep mode.
- CCS disables the OSC, system PLL, e300 Core Processor PLL and gates the system clocks.

#### 5.4.4.2 Exiting Deep Sleep

When exiting Deep Sleep mode, the following occurs:

- CCS receives an interrupt from a GPIO pin, RTC or a MSCAN peripheral.
- CCS enables the OSC and waits for the OSC to stabilize.
- CCS enables the system PLL and waits for the PLL to lock to the OSC clock.
- CCS enables system clocks.
- CCS enables the e300 Core Processor PLL and waits for the PLL to lock to the system PLL clock.
- CCS enables interrupts, which triggers a wakeup interrupt to the e300 Core Processor (from the WakeUp source).
- e300 Core Processor wakes up and puts MPC5200B into full power mode and then services the wakeup interrupt

Waking up from Deep Sleep mode does not require the system to be reset or a boot sequence. The functional state of MPC5200B should remain the same as when it went into Deep Sleep. If the SDRAM was put into self refresh mode, its contents should also remain unchanged.

## 5.5 CDM Registers

The Clock Distribution Module (CDM) contains 14 32-bit registers. All registers are located at an offset from the value in the Module Base Address Register (MBAR). The CDM base offset is 0x0200.

### 5.5.1 Register Descriptions

Hyperlinks to the CDM registers are provided below:

- CDM JTAG ID Number Register (0x0200), read-only
- CDM Power On Reset Configuration Register (0x0204)
- CDM Bread Crumb Register (0x0208), never reset
- CDM Configuration Register (0x020C)
- CDM 48 MHz Fractional Divider Configuration Register Field Descriptions (0x0210)
- CDM Clock Enable Register (0x0214)
- CDM System Oscillator Configuration Register (0x0218)
- CDM Clock Control Sequencer Configuration Register (0x021C)
- CDM Soft Reset Register (0x0220)
- CDM System PLL Status Register (0x0224)
- PSC1 Mclock Configuration Register (0x0228)
- CDM PSC2 Mclock Configuration Register (0x022C)
- CDM PSC3 Mclock Configuration Register (0x0230)
- CDM PSC6 Mclock Configuration Register Field Descriptions (0x0234)

### 5.5.1.1 CDM JTAG ID Number Register

The CDM JTAG ID Number Register is a read-only register that contains the JTAG Identification number identifying MPC5200B. The value is hard coded (1001 101D hex) and cannot be modified.

Address MBAR + 0x0200

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | JTAG Identification Number Register | | | | | | | | | | | | | | | |
| W | Unused | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | JTAG Identification Number Register | | | | | | | | | | | | | | | |
| W | Unused7 | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |

**Figure 5-4. CDM JTAG ID Number Register**

Device I.D. Register = 1001 101D hex

**Table 5-8. CDM JTA ID Numbering**

| Version | Device (MPC5200B) | Manufacturer (Freescale) | |
|---|---|---|---|
| 0001 | 0000 0000 0001 0001 | 0000 0001 110 | 1 |

### 5.5.1.2 CDM Power On Reset Configuration Register

This is a mostly read-only register containing the configuration value latched at POR.

Address MBAR + 0x0204

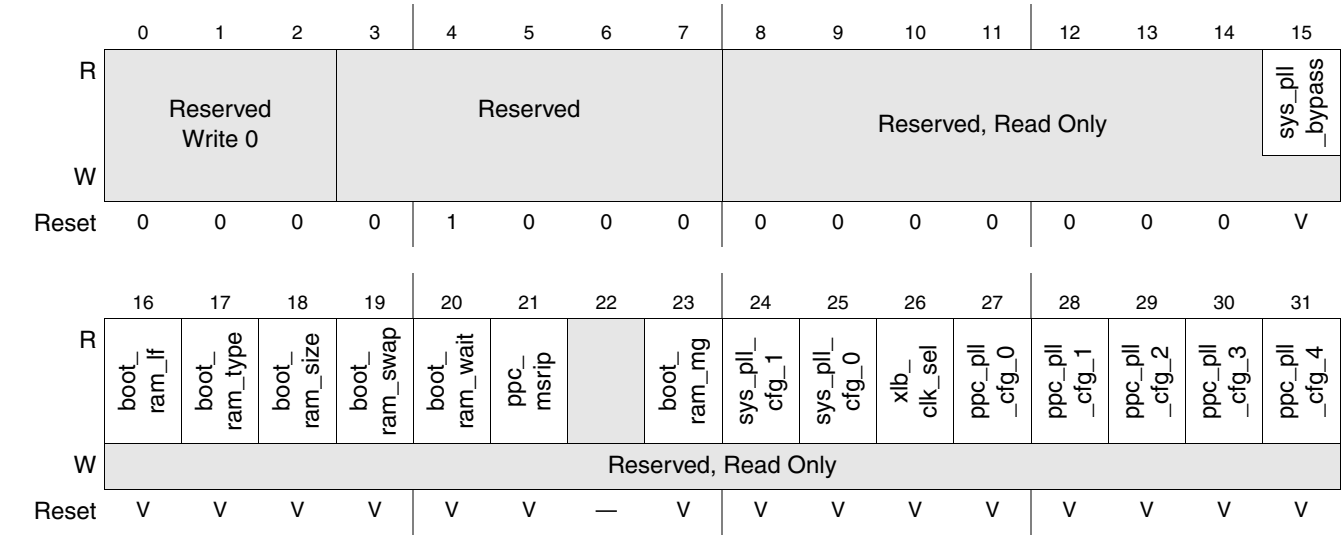



**Figure 5-5. CDM Power On Reset Configuration Register**

**Table 5-9. CDM Power On Reset Configuration Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0–2 | — | Reserved for future use. Write 0. |
| 3–7 | — | Reserved. |
| 8-14 | — | Read Only. Do not write. |
| 15 | sys_pll_bypass | bit=0:Normal mode. The SYS OSC clock input is multiplied up by the system PLL, then the PLL VCO is divided down to produce internal clocks.<br>bit=1:The SYS OSC clock input is used directly, bypassing the system PLL. No multiplication of the input frequency is performed, but the input frequency is divided to produce internal clocks just as the system PLL VCO frequency would be. sys_pll_cfg_1 and sys_pll_cfg_0 are ignored. |
| 16 | boot_rom_lf | Large Flash mode is selected |
| 17 | boot_rom_type | Latched pin value at reset.<br>bit=0:non-muxed boot ROM bus, single tenure transfer.<br>bit=1:muxed boot ROM bus, with address and data tenures, $\overline{\text{ALE}}$ and $\overline{\text{TS}}$ active. |
| 18 | boot_rom_size | Latched pin value at reset.<br>For non-muxed boot ROMs:<br>bit=0:8bit boot ROM data bus, 24bit max boot ROM address bus<br>bit=1:16bit boot ROM data bus, 16bit boot ROM address bus<br>For muxed boot ROMs:<br>boot ROM address is max 25 significant bits during address tenure.<br>bit=0:16bit ROM data bus<br>bit=1:32bit ROM data bus |

**Table 5-9. CDM Power On Reset Configuration Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 19 | boot_rom_swap | Latched pin value at reset.<br>bit=0:no byte lane swap, same endian ROM image<br>bit=1:byte lane swap, different endian ROM image |
| 20 | boot_rom_wait | Latched pin value at reset.<br>bit=0:4 PCI clocks of wait state<br>bit=1:48 PCI clocks of wait state |
| 21 | ppc_msrip | Latched pin value at reset.<br>microprocessor Boot Address/Exception table location.<br>bit=0:0000_0100 (hex)<br>bit=1:FFF0_0100 (hex) |
| 22 | — | Read Only. Do not write. |
| 23 | boot_rom_mg | Most/Graphic Mode is selected as BOOT mode |
| 24 | sys_pll_cfg_1 | Latched pin value at reset.<br>bit=0:No operation.<br>bit=1:Internal System PLL frequency multiplication ratio specified by sys_pll_cfg_0 is doubled (24x, 32x). No net effect on any internal clocks, except that PLL VCO runs twice as fast. Useful in low frequency applications to keep VCO frequency ($f_{vcosys}$) above min, see MPC5200B Hardware Specification. |
| 25 | sys_pll_cfg_0 | Latched pin value at reset.<br>bit=0: $f_{system}$=16x SYS_XTAL_IN Frequency<br>bit=1: $f_{system}$=12x SYS_XTAL_IN Frequency |
| 26 | xlb_clk_sel | Latched pin value at reset.<br>bit=0:XLB_CLK= $f_{system}$ / 4<br>bit=1:XLB_CLK= $f_{system}$ / 8 |
| 27 | ppc_pll_cfg_0 | e300 Core core pll configuration pins. See also Table 5-6 |
| 28 | ppc_pll_cfg_1 | |
| 29 | ppc_pll_cfg_2 | |
| 30 | ppc_pll_cfg_3 | |
| 31 | ppc_pll_cfg_4 | |

### 5.5.1.3 CDM Bread Crumb Register

The CDM Bread Crumb Register is a 32-bit register that is not reset. Its purpose is to let firmware designers leave some status code before entering a reset condition. Since this register is never reset, the value written is available after the reset condition has ended. There is no additional functionality to this register.

Address MBAR + 0x0208

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | CDM Bread Crumb Register (Never Reset) | | | | | | | | | | | | | | | |
| Reset | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | CDM Bread Crumb Register (Never Reset) | | | | | | | | | | | | | | | |
| Reset | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |

**Figure 5-6. CDM Bread Crumb Register**

### 5.5.1.4 CDM Configuration Register

The CDM Configuration Register contains 3 bits that set IPB_CLK and PCI_CLK ratios.

Address MBAR + 0x020C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved Write 0 | | | | | | | ddr_ mode | Reserved Write 0 | | | | | | | xlb_ clk_sel |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | V |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved Write 0 | | | | | | | ipb_ clk_sel | Reserved Write 0 | | | | | | pci_ clk_sel | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Figure 5-7. CDM Configuration Register**

**Table 5-10. CDM Configuration Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0–6 | — | Reserved for future use. Write 0. |
| 7 | ddr_mode | SDRAM Controller DDR memory mode, read-only.<br>bit=0: SDRAM Controller configured for SDR SDRAM (single data rate)<br>bit=1: SDRAM Controller configured for DDR SDRAM (double data rate)<br>This register location is a read-only status bit; write 0. The controlling register is in the SDRAM Controller register map. In the CDM this bit determines the frequency and phase of memory read clock. |

**Table 5-10. CDM Configuration Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 8–14 | — | Reserved for future use. Write 0. |
| 15 | xlb_clk_sel | XLB Clock Frequency<br>bit=0:XLB CLK = $f_{system}$ /4<br>bit=1:XLB CLK = $f_{system}$ /8<br>This register location is a read-only status bit. The controlling register is the POR Configuration register - cdm configuration register [26]. |
| 16–22 | — | Reserved for future use. Write 0. |
| 23 | ipb_clk_sel | IPB Clock Select<br>bit=0:IPB CLK = XLB_CLK<br>bit=1:IPB CLK = XLB_CLK/2 |
| 24–29 | — | Reserved for future use. Write 0. |
| 30-31 | pci_clk_sel | PCI Clock Select<br>00–PCI_CLK = IPB_CLK<br>01–PCI_CLK = IPB_CLK/2<br>10–PCI_CLK = XLB_CLK/4<br>See also Table 5-3 and Table 5-4. |

**NOTE**

The clock ratio should only be changed if no module, which is clocked by the IPB and/or PCI clock, is currently running. Suggestion is to change the clock ratio during the boot time only.

### 5.5.1.5 CDM 48MHz Fractional Divider Configuration Register

The CDM 48MHz Fractional Divider Configuration Register contains the control bits used in the 48MHz fractional divider.

Address MBAR + 0x210

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved<br>Write 0 | | | | | ext_usb_<br>sync_en | ext_usb_<br>48mhz_en | ext_irda_<br>48mhz_en | Reserved<br>Write 0 | | | | | | | fd_en |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Rsrvd<br>Write 0 | cfgd_p3_cnt | | | Rsrvd<br>Write 0 | cfgd_p2_cntt | | | Rsrvd<br>Write 0 | cfgd_p1_cnt | | | Rsrvd<br>Write 0 | cfgd_p0_cnt | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 5-8. CDM 48 MHz Fractional Divider Configuration Register**

**Table 5-11. CDM 48 MHz Fractional Divider Configuration Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0–4 | — | Reserved for future use. Write 0. |
| 5 | ext_usb_sync_en | Enable the synchronization logic which synchronize the external ext_usb_48Mhz clock to the internal clock system.<br>bit=1: ext USB 48MHz clock is synchronized to the internal clock system.<br>bit=0: ext USB 48MHz clock is not synchronized to the internal clock system. |
| 6 | ext_usb_48MHz_en | USB External 48MHz Clock Select<br>bit=1: USB 48MHz clock tree sourced from external clock from GPIO.<br>bit=0: USB 48MHz clock tree sourced from CDM Fractional Divider. |
| 7 | ext_irda_48MHz_en | IrDA (PSC6) External 48MHz Clock Select<br>bit=1: IRDA 48MHz clock tree sourced from external clock from GPIO.<br>bit=0: IRDA 48MHz clock tree sourced from CDM Fractional Divider. |
| 8–14 | — | Reserved for future use. Write 0. |
| 15 | fd_en | CDM 48MHz Fractional Divider Enable<br>bit=1: enable CDM Fractional Divider.<br>bit=0: disable CDM Fractional Divider. |
| 16 | — | These fields hold 4 phase divide ratios used by the fractional divider. The fields are incompletely decoded; $f_{system}/11$ is obtained with 3 values.<br>110–fractional counter divide ratio $f_{system}/6$<br>111–fractional counter divide ratio $f_{system}/7$<br>000–fractional counter divide ratio $f_{system}/8$<br>001–fractional counter divide ratio $f_{system}/9$<br>010–fractional counter divide ratio $f_{system}/10$<br>011–fractional counter divide ratio $f_{system}/11$<br>10X–fractional counter divide ratio $f_{system}/11$ |
| 17–19 | cgfd_p3_cnt[2:0] | |
| 20 | — | |
| 21–23 | cgfd_p2_cnt[2:0] | |
| 24 | — | |
| 25–27 | cgfd_p1_cnt[2:0] | |
| 28 | — | |
| 29–31 | cgfd_p0_cnt[2:0] | |

### 5.5.1.6 CDM Clock Enable Register

The CDM Clock Enable Register, or power management register, contains control bits that enable/disable peripheral clocks. Unused peripherals can have their clock stopped, reducing power consumption.

Address MBAR + 0x0214

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved<br>Write 0 | | | | | | | | | | | | mem_<br>clk_en | pci_<br>clk_en | lpc_<br>clk_en | slt_<br>clk_en |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | scom_<br>clk_en | ata_<br>clk_en | eth_<br>clk_en | usb_<br>clk_en | spi_<br>clk_en | bdlc_clk_<br>en | psc5_<br>clk_en | psc4_<br>clk_en | psc3_<br>clk_en | psc2_<br>clk_en | psc1_<br>clk_en | psc6<br>clk_en | mscan_<br>clk_en | i2c_<br>clk_en | timer_<br>clk_en | gpio_<br>clk_en |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Figure 5-9. CDM Clock Enable Register**

**Table 5-12. CDM Clock Enable Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | — | Reserved for test. Write 0. |
| 1–11 | — | Reserved for future use. Write 0. |
| 12 | mem_clk_en | Memory Clock Enable—controls SDRAM Controller module clocks<br>Memory Controller IPB_CLK is not controlled by mem_clk_en. |
| 13 | pci_clk_en | PCI Bus Clock Enable—controls PCI bus control module clocks<br>**Note:** PCI Arbiter and external PCI Bus clocks are not controlled by pci_clk_en. |
| 14 | lpc_clk_en | Local Plus Bus Clock Enable—controls LP bus control module clocks |
| 15 | slt_clk_en | Slice Timer Clock Enable—controls slice timer module clocks |
| 16 | scom_clk_en | BestComm Clock Enable—controls BestComm module clocks |
| 17 | ata_clk_en | ATA Clock Enable—controls ATA disk drive control module clocks |
| 18 | eth_clk_en | Ethernet Clock Enable—controls Ethernet Controller module clocks |
| 19 | usb_clk_en | Universal Serial Bus Clock Enable—controls USB module clock |
| 20 | spi_clk_en | SPI Clock Enable—controls SPI module clocks |
| 21 | bdlc_clk_en | BDLC Clock Enable—controls BDLC module clocks |
| 22 | psc5_clk_en | PSC5 Clock Enable—control clock to the PSC5 module |
| 23 | psc4_clk_en | PSC4 Clock Enable—control clock to the PSC4 module |
| 24 | psc3_clk_en | PSC3 Clock Enable—control clock to the PSC3 module |
| 25 | psc2_clk_en | PSC2 Clock Enable—control clock to the PSC2 module |
| 26 | psc1_clk_en | PSC1 Clock Enable—control clock to the PSC1 module |

**Table 5-12. CDM Clock Enable Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 27 | psc6_clk_en | PSC6 Clock Enable—control clock to the PSC6 module |
| 28 | mscan_clk_en | MSCAN Clock Enable—controls MSCAN module clocks |
| 29 | i2c_clk_en | I2C Clock Enable—controls $I^2C$ module clocks |
| 30 | timer_clk_en | Timer Clock Enable—controls timer module clocks<br>**Note:** 2 timers for wake-up mode do not have gated clocks. |
| 31 | gpio_clk_en | GPIO Clock Enable—controls some GPIO module clocks<br>**Note:** GPIO wake-up mode circuitry uses free running IPB_CLK |

**Note:** An enable value of 1 enables the corresponding clock. An enable value of 0 disables corresponding clock.

### 5.5.1.7 CDM System Oscillator Configuration Register

This register contains the System Oscillator disable bit. The system oscillator is disabled if an external clock source (not a crystal) drives the oscillator in package pin. The crystal oscillator pad cell is disabled to reduce power consumption (~6mW for system oscillator).

Address MBAR + 0x0218

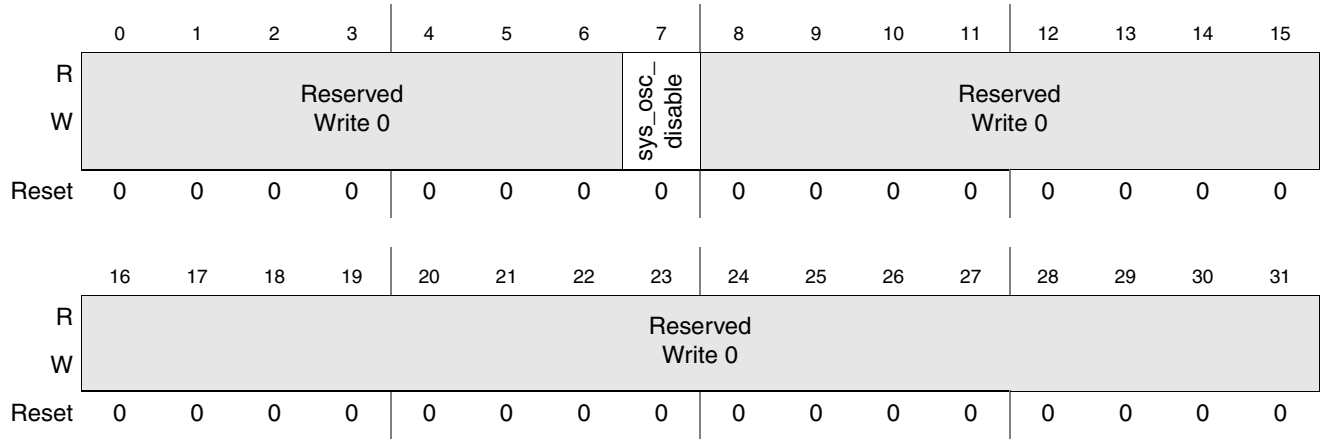



**Figure 5-10. CDM System Oscillator Configuration Register**

**Table 5-13. CDM System Oscillator Configuration Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0–6 | — | Reserved for future use. Write 0. |
| 7 | sys_osc_disable | CDM System Oscillator Disable<br>bit=1: System Oscillator is disabled. External clock source is required.<br>bit=0: System Oscillator is enabled. 27–33MHz crystal is being used. |
| 8–31 | — | Reserved for future use. Write 0. |

### 5.5.1.8 CDM Clock Control Sequencer Configuration Register

This register contains the configuration that controls the CCS module. The CCS module lets MPC5200B enter deep sleep power down mode (all clocks stopped).

Address MBAR + 0x021C

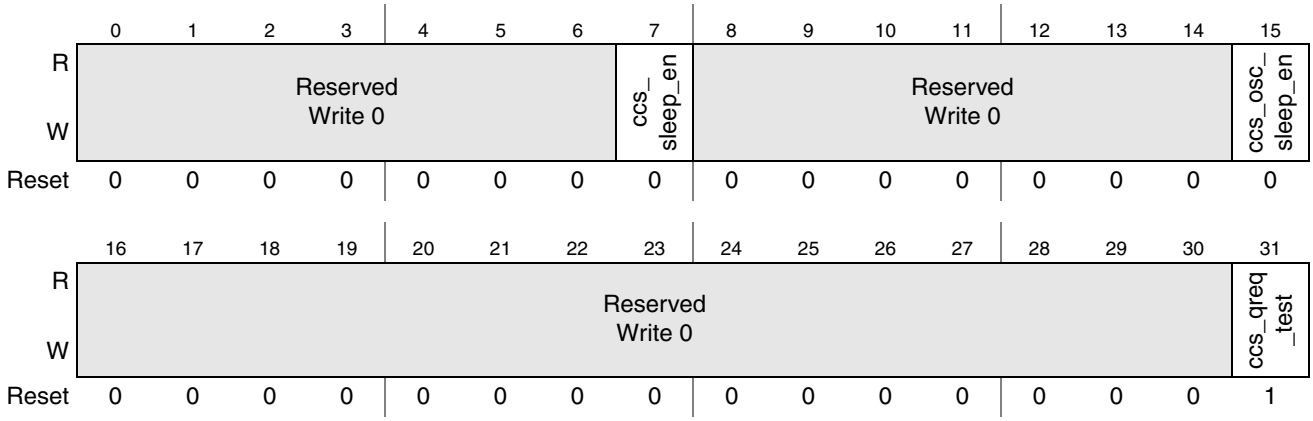



**Figure 5-11. CDM Clock Control Sequencer Configuration Register**

**Table 5-14. CDM Clock Control Sequencer Configuration Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0–6 | — | Reserved for future use. Write 0. |
| 7 | ccs_sleep_en | CCS Module Enable<br>bit=1: CCS enabled. e300 Core QREQ signal triggers deep sleep cycle.<br>bit=0: CCS disabled and inactive. No deep sleep mode possible.<br>**Note:** This bit should only be set before the processor should go into deep sleep mode. And it should be reset after wake up.<br>**Note:** It is not allowed to set this bit if a JTAG debugger or the nap mode should be used. |
| 8–14 | — | Reserved for future use. Write 0. |
| 15 | ccs_osc_sleep_en | CCS System Oscillator Disable Control<br>bit=1: CCS can disable System Oscillator in deep sleep mode.<br>bit=0: CCS cannot disable System Oscillator in deep sleep mode. Oscillator remains active. |
| 16–30 | — | Reserved for future use. Write 0. |
| 31 | ccs_qreq_test | CCS Test bit—Used in CCS module functional simulation to simulate a QREQ signal.<br>bit=0: QREQ input to CCS forced active.<br>bit=1: QREQ input to CCS comes directly from e300 Core. |

### 5.5.1.9 CDM Soft Reset Register

This register contains 2 reset control bits.

Address MBAR + 0x0220

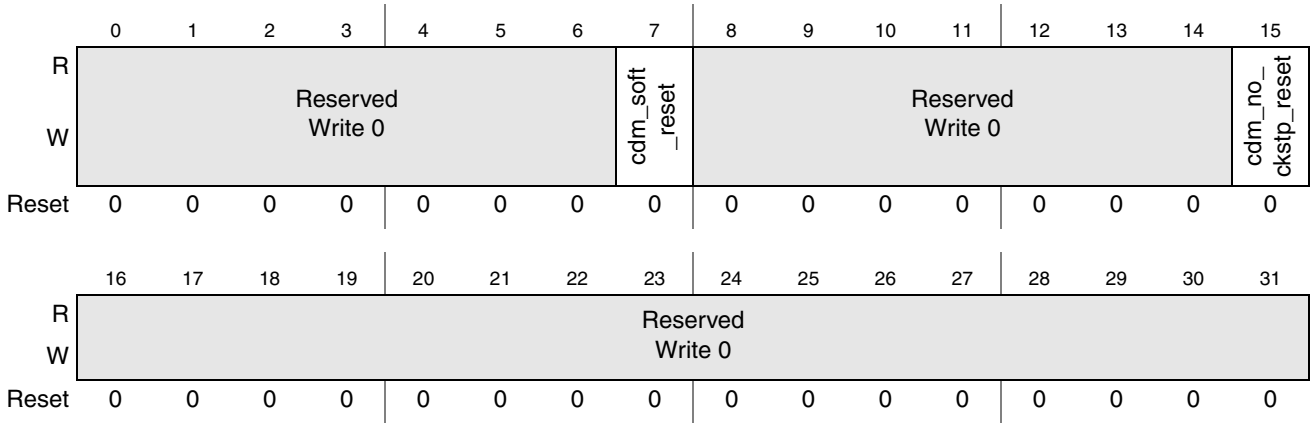



**Figure 5-12. CDM Soft Reset Register**

**Table 5-15. CDM Soft Reset Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0–6 | — | Reserved for future use. Write 0. |
| 7 | cdm_soft_reset | CDM Soft Reset bit.<br>bit=0: requests CDM soft reset.<br>bit=1: CDM soft reset request inactive. |
| 8–14 | — | Reserved for future use. Write 0. |
| 15 | cdm_no_ckstp_reset | CDM No reset on checkstop.<br>bit=0: Checkstop assertion causes HRESET.<br>bit=1: Checkstop assertion does not cause HRESET. |
| 16–31 | — | Reserved for future use. Write 0. |

### 5.5.1.10 CDM System PLL Status Register

This register contains control and status bits of the CDM PLL lock detect module.

Address MBAR + 0x0224

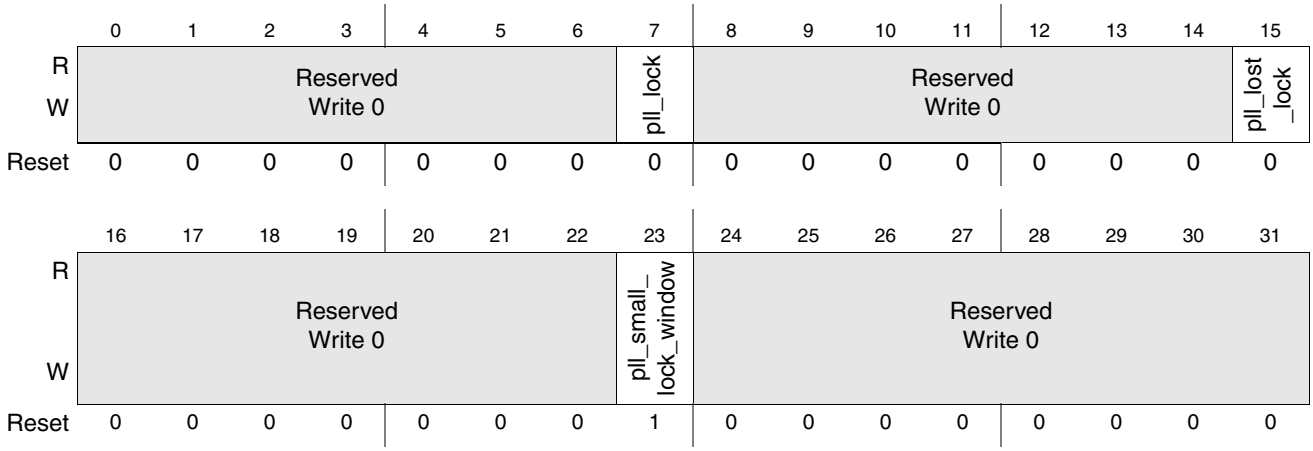

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
R
W
Reserved Write 0
pll_lock
Reserved Write 0
pll_lost_lock
Reset 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
R
W
Reserved Write 0
pll_small_lock_window
Reserved Write 0
Reset 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0

**Figure 5-13. CDM System PLL Status Register**

**Table 5-16. CDM System PLL Status Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0–6 | — | Reserved for future use. Write 0. |
| 7 | pll_lock[1] | CDM System PLL Lock Detect—read-only status bit.<br>bit=1: CDM has detected System PLL lock condition.<br>bit=0: CDM has NOT detected System PLL lock condition. |
| 8–14 | — | Reserved for future use. Write 0. |
| 15 | pll_lost_lock | CDM System PLL Lock Lost—hardware can only set this bit, register write must clear bit.<br>bit=1: CDM detected loss of PLL lock after PLL lock has been achieved.<br>bit=0: CDM has not detected loss of PLL lock (state before PLL lock occurs). |
| 16–22 | — | Reserved for future use. Write 0. |
| 23 | pll_small_lock_window | PLL Small Lock Window—pulse width used to detect rising edge of PLL FREF clock.<br>bit=1: lock window pulse width 2 $f_{VCOsys}$ clock periods.<br>bit=0: lock window pulse width 4 $f_{VCOsys}$ clock periods. |
| 24–31 | — | Reserved for future use. Write 0. |

**Note:**

1. System PLL Lock Condition—256 System PLL FREF clock rising edges within PLL_Lock_Window (System PLL FFB rising edge). In PLL bypass mode, Lock is active after 256 System Oscillator clock rising edges.
2. In current MPC5200B CDM the PLL Lock Circuitry is for information only. CDM does not wait for PLL lock to start clocks or use PLL_LOST_LOCK as an interrupt source.

### 5.5.1.11 PSC1 Mclock Configuration Register

This register controls the generation of the Mclk for PSC1. Before modify the register value the divider must be disabled.

Address MBAR + 0x0228

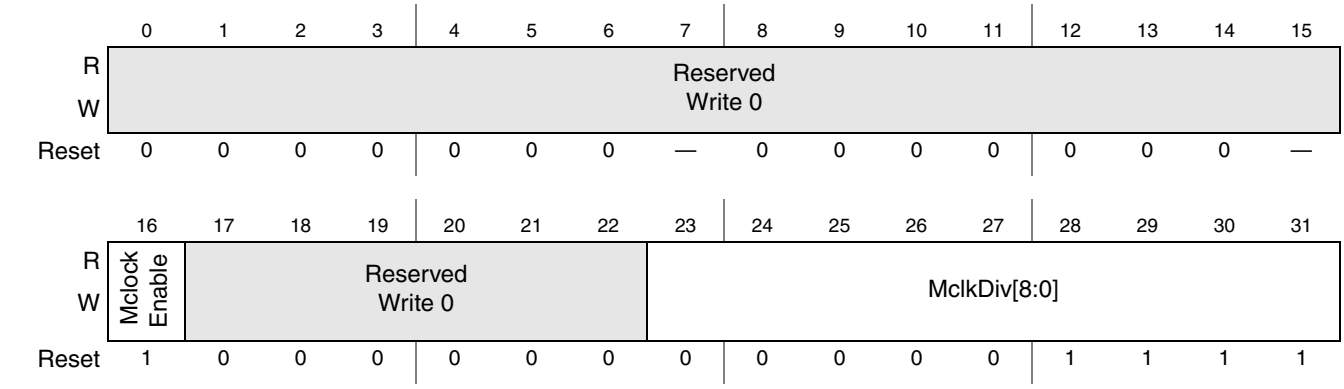



**Figure 5-14. CDM PSC1 Mclock Configuration Register**

**Table 5-17. CDM PSC1 Mclock Configuration Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0–15 | — | Reserved for future use. Write 0. |
| 16 | Mclock Enable | PSC1 Mclock enable.<br>bit=0: Turns off internally generated Mclock.<br>bit=1: Turns on internally generated Mclock. |
| 17-22 | — | Reserved for future use. Write 0. |
| 23-31 | MclkDiv[8:0] | The counter divide the $f_{system}$ frequency by MclkDiv+1. A value of 0x00 in this register turns off internally generated Mclock.<br>For example, a value of 7 in this register, where fsystem clock is at a frequency of 528MHz would result in a Mclock rate of 528/8, or 66 MHz.<br>**Note:** $f_{system}$ clock is always 12 or 16 times the reference clock, sys_xtal_in, depending on sys_pll_cfg_0 at reset. |

### 5.5.1.12 PSC2 Mclock Configuration Register

This register controls the generation of the Mclock for PSC2. Before modify the register value the divider must be disabled.

Address MBAR + 0x022C

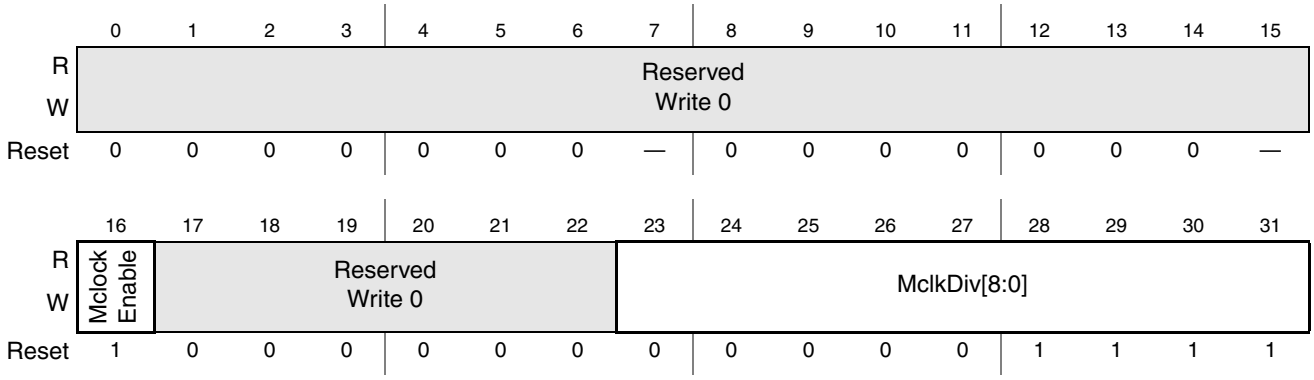



**Figure 5-15. CDM PSC2 Mclock Configuration Register**

**Table 5-18. CDM PSC2 Mclock Configuration Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0–15 | — | Reserved for future use. Write 0. |
| 16 | Mclock Enable | PSC2 Mclock enable.<br>bit=0: Turns off internally generated Mclock.<br>bit=1: Turns on internally generated Mclock. |
| 17-22 | — | Reserved for future use. Write 0. |
| 23-31 | MclkDiv[8:0] | The counter divide the $f_{system}$ frequency by MclkDiv+1. A value of 0x00 in this register turns off internally generated Mclock.<br>For example, a value of 7 in this register, where fsystem clock is at a frequency of 528MHz would result in a Mclock rate of 528/8, or 66 MHz.<br>**Note:** $f_{system}$ clock is always 12 or 16 times the reference clock, sys_xtal_in, depending on sys_pll_cfg_0 at reset. |

### 5.5.1.13 PSC3 Mclock Configuration Register

This register controls the generation of the Mclock for PSC3. Before modify the register value the divider must be disabled.

Address MBAR + 0x0230

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved<br>Write 0 | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | — | 0 | 0 | 0 | 0 | 0 | 0 | 0 | — |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Mclock Enable | Reserved<br>Write 0 | | | | | | | MclkDiv[8:0] | | | | | | | |
| Reset | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |

**Table 5-19. CDM PSC3 Mclock Configuration Register**

**Table 5-20. CDM PSC3 Mclock Configuration Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0–15 | — | Reserved for future use. Write 0. |
| 16 | Mclock Enable | PSC3 Mclock enable.<br>bit=0: Turns off internally generated Mclock.<br>bit=1: Turns on internally generated Mclock. |
| 17-22 | — | Reserved for future use. Write 0. |
| 23-31 | MclkDiv[8:0] | The counter divide the $f_{system}$ frequency by MclkDiv+1. A value of 0x00 in this register turns off internally generated Mclock.<br>For example, a value of 7 in this register, where fsystem clock is at a frequency of 528MHz would result in a Mclock rate of 528/8, or 66 MHz.<br>**Note:** $f_{system}$ clock is always 12 or 16 times the reference clock, sys_xtal_in, depending on sys_pll_cfg_0 at reset. |

### 5.5.1.14 PSC6 (IrDA) Mclock Configuration Register

This register controls the generation of the Mclock for PSC6. Before modify the register value the divider must be disabled.

Address MBAR + 0x0234

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved<br>Write 0 | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | — | 0 | 0 | 0 | 0 | 0 | 0 | 0 | — |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Mclock Enable | Reserved<br>Write 0 | | | | | | | MclkDiv[8:0] | | | | | | | |
| Reset | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |

**Figure 5-16. CDM PSC6 Mclock Configuration Register**

**Table 5-21. CDM PSC6 Mclock Configuration Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0–15 | — | Reserved for future use. Write 0. |
| 16 | Mclock Enable | PSC6 Mclock enable.<br>bit=0: Turns off internally generated Mclock.<br>bit=1: Turns on internally generated Mclock. |
| 17-22 | — | Reserved for future use. Write 0. |
| 23-31 | MclkDiv[8:0] | The counter divide the $f_{system}$ frequency by MclkDiv+1. A value of 0x00 in this register turns off internally generated Mclock.<br>For example, a value of 7 in this register, where fsystem clock is at a frequency of 528MHz would result in a Mclock rate of 528/8, or 66 MHz.<br>**Note:** $f_{system}$ clock is always 12 or 16 times the reference clock, sys_xtal_in, depending on sys_pll_cfg_0 at reset. |

# Chapter 6
# e300 Processor Core

## 6.1 Overview

The following sections are contained in this document:

- MPC5200B e300 Processor Core Functional Overview
- e300 Core Reference Manual
- Not Supported e300 Core Features

## 6.2 MPC5200B e300 Processor Core Functional Overview

The MPC5200B integrates a e300 processor core based on, and compatible with, the 603e which is a PowerPC compliant microprocessor. The e300 core is completely embedded, as its address, data, and control signals are not visible external to MPC5200B. The e300 core has the following features:

- 603e series PowerPC compliant processor core
- Dual Issue, superscalar architecture
- 16K instruction cache, 16K data cache
- Double precision FPU
- Instruction and data MMU
- Power management modes:
  - Nap
  - Doze
  - Sleep
  - Deep Sleep
- Standard & critical interrupt capability

For additional information on the capabilities and features of the e300 core, refer to 603e user documentation.

The e300 processor has a 32-bit address/64-bit data bus referred to as the 60X Local Bus (XLB). This bus is the main system connecting all internal mastering and slave modules. In addition to the e300 core, the USB host controller, PCI controller (as target) and BestComm controller can master the XLB.

The e300 core fetches 32-bit instructions (one word), two words at a time. After power-on reset, initial boot instructions are fetched from the LocalPlus bus, with CS0 active. The processor can execute code from the local bus or from the SDRAM controller. To facilitate high speed execution, boot code is typically copied from a Flash or ROM device attached to the LocalPlus bus, to SDRAM. The e300 core can execute code from the on-chip SRAM.

The e300 core has memory mapped access to all MPC5200B resources including:

- all on-chip programming registers
- all on-chip FIFOs and memories
- external SDRAM
- internal SRAM
- PCI-controlled address space
- external disk drive control register space (via PIO mode), etc.

When a master device wants access to the XLB, a request is made to the XLB Arbiter. When access is granted, the mastering device controls the XLB during the subsequent address tenure and data tenure.

Bursting is supported on the XLB. Critical Word First protocol is employed when the e300 core attempts to fill its address and data caches. Pipelining and cache coherency support (XLB address snooping) has been added to the MPC5200B to improve performance.

MPC5200B use the version 1.4 of the e300 core. The Processor version register (PVR) is 0x80822014. The e300 core has a System version register (SVR). The SVR numbers of MPC5200B are:

**Table 6-1. SVR Values**

| Revision | SVR |
|---|---|
| M08A | 80110020 |
| M62C | 80110021 |

## 6.3 e300 Core Reference Manual

A complete specification for the e300 core implementation used on the MPC5200B is obtained through a collection of documentation.

- PowerPC Microprocessor Family: The Programming Environments for 32-bit Microprocessors, Rev. 2: MPCFPE32B/AD
- G2 PowerPC Core Reference Manual, Rev. 1: G2CORERM/D

The programming environments manual provides information about resources defined by the PowerPC architecture that are common to PowerPC processors. Implementation variances relative to Rev. 2 of the Programming Environments Manual are available in the G2 Core Reference Manual.

The G2 Core Reference Manual can be obtained from the Freescale (formerly Motorola) Literature Distribution center at http://e-www.freescale.com. Click on the Documentation link to proceed to the Semiconductor Documentation Library. In the documentation form window, select “Reference Manual” and set the matching pages option button to “All”. An alphabetical list of reference manuals will appear and the G2 core document ID is ‘G2CORERM/D’. From this line entry, you may order hard copies of the G2 Core Reference Manual or download a PDF copy of the manual.

## 6.4 Not Supported e300 Core Features

### 6.4.1 Not Supported Instruction

The e300 core supports two instructions that are not available by the MPC5200B. These two instructions are **eciowx** and **ecowx**. The execution of both instructions will generate a $\overline{\text{TEA}}$ signal on XLB. This will cause a machine check exception or a checkstop.

### 6.4.2 Not Supported XLB Parity Feature

The e300 core supports an address and data parity error detection for the XL bus. This feature is not supported by the MPC5200B. The core input signals core_ap_in [0:3] are pulled-down to 0 and the core input signals core_dp_in [0:7] are pulled-up to 1. Enabling of the address or data parity error check by the HID0 [EBA, EBD] bits will generate a machine check exception or a checkstop depending on the HID0 [EMCP] bit.

# Chapter 7
# System Integration Unit (SIU)

## 7.1 Overview

The following sections are contained in this document:

- Interrupt Controller, includes:
  - Interrupt Controller Registers
- General Purpose I/O (GPIO), includes:
  - GPIO Standard Registers (MBAR + 0x0B00)
  - WakeUp GPIO Registers (MBAR + 0x0C00)
- General Purpose Timers (GPT), includes:
  - GPT Registers (MBAR + 0x0600)
- Slice Timers, includes:
  - SLT Registers (MBAR + 0x700)
- Real-Time Clock, includes:
  - RTC Interface Registers (MBAR + 0x800)

**NOTE**

Watchdog timer functions are included in the GPT section.

The System Integration Unit (SIU) controls and support the functions listed above.

## 7.2 Interrupt Controller

A highly configurable Interrupt Controller directs all interrupt sources to the following e300 core interrupt pins:

- core_cint — critical interrupt
- core_smi — system management interrupt
- core_int — standard interrupt

### 7.2.1 Block Description

The Interrupt Controller MUXes a variety of interrupt sources to the limited interrupt pins on the e300 core. The interrupt sources and their descriptions are summarized in Table 7-1.

**Table 7-1. Interrupt Sources**

| Source | No. | Description |
|---|---|---|
| External IRQ Interrupts | 4 | Can be programmed as level or edge sensitive. Provides interrupt requests to Interrupt Controller for external devices. |
| Slice Timers | 2 | “Tick” generators. Suitable for operating system update tick. |
| General Timers | 8 | Generates interrupt in Input Capture mode or Internal Timer mode. Timers 6 and 7 can interrupt from NAP/DOZE power-down. |
| BestComm and Peripherals | 19 | Various peripherals are priority programmed and encoded into HI or LO interrupt to the Interrupt Controller. BestComm Controller interrupt is connected to HI interrupt. |
| RTC | 2 | Stopwatch and periodic |
| WakeUp | 8 | These are special GPIO pins with WakeUP capability. There are 8 such pins funneled into one interrupt. The source module is gpio_wkup. |
| GPIO | 8 | GPIO pins with simple interrupt capability (not available in power down mode). The source module is gpio_std. |
| WatchDog Timer | 0 | No vector handler, generates $\overline{\text{SRESET}}$ output indication. |
| Total | 51 | |

Table 7-1 does not include machine-check bus errors or transaction handshaking. e300 core interrupt pins given in Section 7.2.1.1, “Machine Check Pin—core_mcp” through Section 7.2.1.3, “Standard Interrupt—core_int” show e300 core interrupt priority.

### 7.2.1.1 Machine Check Pin—core_mcp

**NOTE**

The core_mcp pin is not used. Bus errors occur on the XL bus, thus generating an internal machine-check exception, or are reflected as a normal interrupt from the offending source module.

Internally, bus errors (TEA, APE, DPE, etc.) cause a machine check exception to a single exception vector. This pin allows additional, external to the e300 core, interrupts of the same type, but is not connected in this device.

### 7.2.1.2 System Management Interrupt—core_smi

The core_smi is a e300 core pin for high priority interrupts. Table 7-2 defines the interrupts.

**Table 7-2. System Management Interrupt Pin Interrupts**

| Interrupt | Description |
|---|---|
| Enables | The MSR[ee] bit must be set to enable interrupts at this e300 core pin. The MSR[ee] bit is automatically cleared when an interrupt occurs. Therefore, the exception handler must re-set this bit when interrupt is cleared. |
| Recovery/Status | Recovery is highly dependant on system and software design. Where multiple sources are tied to the same interrupt, a status register is provided to distinguish the interrupting source. |

**Table 7-2. System Management Interrupt Pin Interrupts (continued)**

| Interrupt | Description |
|---|---|
| Timing | Assertion of this interrupt is persistent (i.e., interrupt remains until cleared). If other interrupts are pending when first interrupt is cleared, the core_smi pin should remain asserted for handling once the current exception handler re-sets the MSR[ee] bit. |
| Connections | Standard external and internal interrupts can be connected to this high priority interrupt. Slice timer 1 is a dedicated connection. |

### 7.2.1.3 Standard Interrupt—core_int

Identical to core_smi, but of lower priority. This interrupt is shared by a variety of internal low priority interrupts such as GPIO and RTC functions. Some programmable connection are provided. Table 7-3 gives a summary of the interrupt pins. Figure 7-2 shows the interrupt sources and e300 core pins.

**Table 7-3. e300 core Interrupt Pins Summary**

| Pin | Description | Sources | To Enable | Timing |
|---|---|---|---|---|
| core_mcp | Machine Check Pin | Tied inactive | — | — |
| core_cint | Critical Interrupt | BestComm HI, IRQ0, Slice Timer 0, CCS WakeUp | MSR[ce] | Persistent (remains until cleared) |
| core_smi | System Management Interrupt | Slice Timer 1, Programmable interrupts | MSR[ee] | Persistent |
| core_int | Standard Interrupt | Programmable interrupts | MSR[ee] | Persistent |

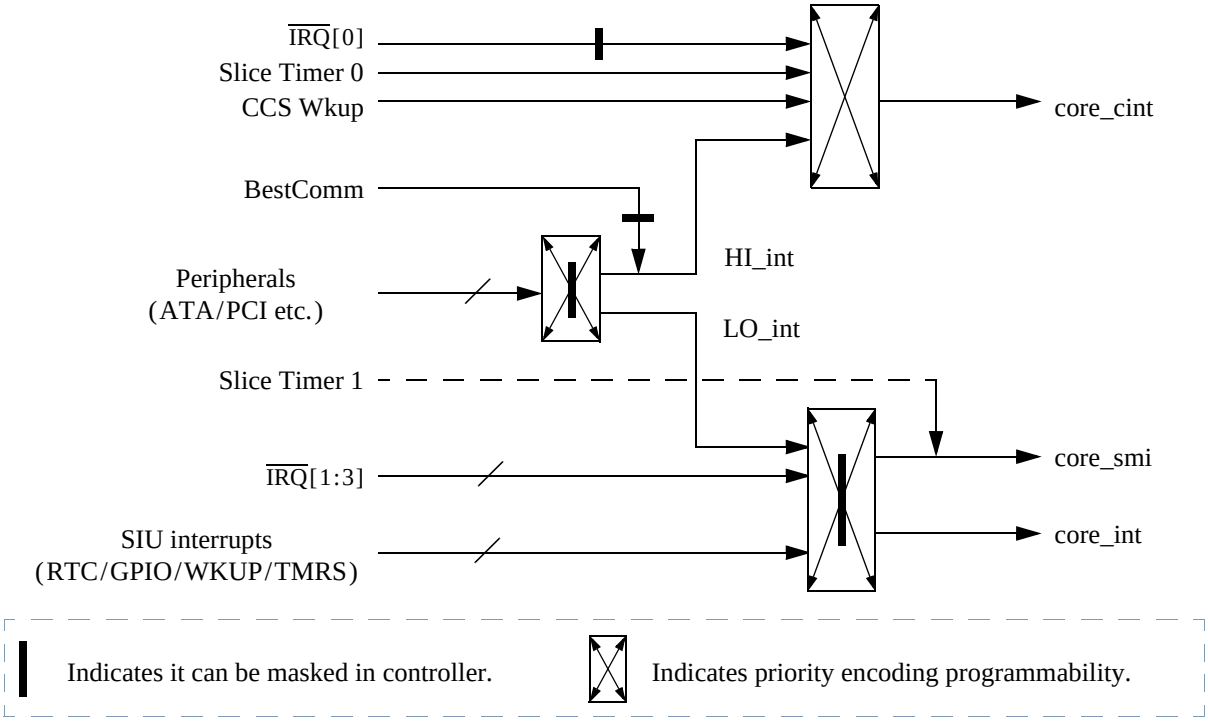



**Figure 7-1. Interrupt Sources and e300 core Interrupt Pins**

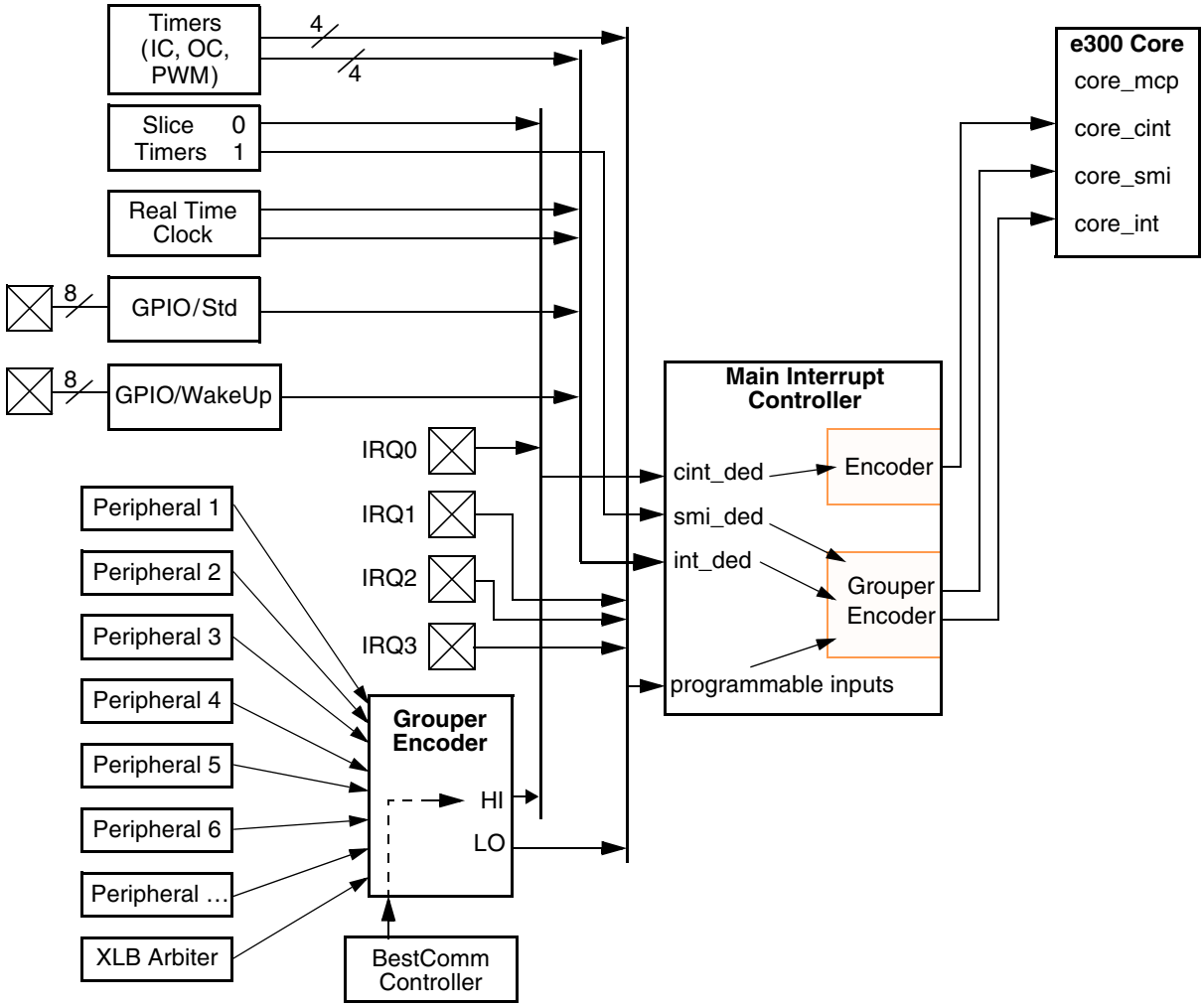
$\overline{IRQ}$[0:3] Interrupt Requests

$\overline{IRQ}$[0:3] provides interrupt requests to Interrupt Controllers for external devices such as:

- Graphics controllers
- PCI interrupt controller
- ATAs
- Transport de-multiplexers
- External I/O devices, etc.

These interrupts are programmable as edge or level sensitive. See Figure 7-1.

## 7.2.2 Interface Description




NOTE:
1. Grouper and Encoder functions imply programmability in software.

**Figure 7-2. Interrupt Controller Routing Scheme**

### 7.2.3 Programming Note

Under specific conditions, the Interrupt Controller may not support nested interrupts. The Interrupt Controller may prevent the assertion of a core_cint interrupt if a core_int or a core_smi is pending. Similarly, the Interrupt Controller may block a core_smi if a core_int is pending. If the e300 core received the core_cint assertion during an core_int or core_smi assertion, it would preempt the current interrupt service routine and process the Critical Interrupt Service routine immediately. Since the MPC5200B Interrupt Controller postpones the core_cint assertion until after a current core_int or core_smi is finished, there can be a delay before the 603e receives and services Critical Interrupt Sources.

The interrupt Controller always supports nested interrupt if the Critical Interrupt sources come from IRQ0, Slice TImer 0 or the wakeup logic. There is a difference when the critical source comes from HI_int (Peripheral Interrupt Group). As shown in Figure 7-2, each Peripheral Interrupt can assert a HI_int or LO_int condition. But only one Peripheral Interrupt can be active at the time, so the Interrupt Controller has not the ability to simultaneously assert both HI_int and LO_int. Therefore, the peripheral 2 which generated by default a core_int (LO_int) interrupt will prevent a BestComm Interrupt to generate a core_cint (HI_int) interrupt.

In addition, a Peripheral Interrupt directed to a core_cint can be prevented by a pending core_smi interrupt. Each Peripheral Interrupt (LO_int) can be programmed to cause a core_smi by setting the Main4_pri msb. Once again, the Interrupt Controller does not has the ability to simultaneously generate the HI_int and LO_int. Then, a Peripheral Interrupt, which generates a core_smi, prevents any Peripheral Interrupts to assert a core_cint.

Similarly, the Interrupt Controller can activate only one Main Interrupt source at the time. Main4 source is the collection of all LO_int Peripheral Interrupts. The Main4_pri can be programmed in order to generate a core_smi or a core_int. As result, a Peripheral Interrupt that causes a core_int will prevent all other Main Interrupt sources to generate a core_smi. Although the Interrupt Controller does not exhibit the correct behavior, the e300 core always completes the core_int before treating the core_smi. In this case, the CPU does not authorize nested interrupt at the exception if the ISR set the 603e's MSR[EE] to support nested interrupt (core_smi and core_int).

In order to guaranty the assertion of the core_cint when a core_int is pending, the ISR needs to force the re-evaluation of the Peripheral Interrupt condition by writing "1" to the Peripheral Status Encoded Pse msb. The ISR has to repeatedly set this bit since the interrupt events are indeterministic. Moreover, the Peripheral Interrupt sources directed to core_cint needs to have their priorities to be higher than the LO_int Peripheral Interrupt sources. The Interrupt Controller always activates first the pending interrupt having the highest priority. Like for the Peripheral Interrupt Group, the ISR needs to set the Main Status Encoded MSe msb to force re-evaluation of the Main Interrupt Condition and each Main Interrupt Priority needs to be properly programmed.

### 7.2.4 Interrupt Controller Registers

The Interrupt Controller uses 13 32-bit registers. These registers are located at an offset from MBAR of 0x0500. Register addresses are relative to this offset. Therefore, the actual register address is: MBAR + 0x0500 + register address.

Hyperlinks to the Interrupt Controller registers are provided below:

- ICTL Peripheral Interrupt Mask Register (0x0500)
- ICTL Peripheral Priority and HI/LO Select 1 Register (0x0504)
- ICTL Peripheral Priority and HI/LO Select 2 Register (0x0508)
- ICTL Peripheral Priority and HI/LO Select 3 Register (0x050C)
- ICTL External Enable and External Types Register (0x0510)
- ICTL Critical Priority and Main Interrupt Mask Register (0x0514)
- ICTL Main Interrupt Priority and INT/SMI Select 1 Register (0x0518)
- ICTL Main Interrupt Priority and INT/SMI Select 2 Register (0x051C)
- ICTL PerStat, MainStat, CritStat Encoded Register (0x0524)
- ICTL Critical Interrupt Status All Register (0x0528)
- ICTL Main Interrupt Status All Register (0x052C)
- ICTL Peripheral Interrupt Status All Register (0x0530)
- ICTL Bus Error Status Register (0x0538)
- ICTL Main Interrupt Emulation All Register (0x0540)
- ICTL Peripheral Interrupt Emulation All Register (0x0544)
- ICTL IRQ Interrupt Emulation All Register (0x0544)

### 7.2.4.1 ICTL Peripheral Interrupt Mask Register

Address MBAR + 0x0500

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Per_mask | | | | | | | | | | | | | | | |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Per_mask | | | | | | | | Reserved | | | | | | | |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-3. ICTL Peripheral Interrupt Mask Register**

**Table 7-4. ICTL Peripheral Interrupt Mask Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| — | Per_mask | Bits 0:23—To mask/accept individual peripheral interrupt sources. This masking is in addition to interrupt enables, which may exist in each source module.<br>0 Accept interrupt from source module.<br>1 Ignore interrupt from source module.<br>Important—See Note [1]. |
| 0 | Per_mask | BestComm interrupt source |
| 1 | Per_mask | Peripheral 1 (PSC1) |
| 2 | Per_mask | Peripheral 2 (PSC2) |
| 3 | Per_mask | Peripheral 3 (PSC3) |
| 4 | Per_mask | Peripheral 4 (PSC6) |
| 5 | Per_mask | Peripheral 5 (Ethernet) |
| 6 | Per_mask | Peripheral 6 (USB) |
| 7 | Per_mask | Peripheral 7 (ATA) |
| 8 | Per_mask | Peripheral 8 (PCI Control module) |
| 9 | Per_mask | Peripheral 9 (PCI SC Initiator RX) |
| 10 | Per_mask | Peripheral 10 (PCI SC Initiator TX) |
| 11 | Per_mask | Peripheral 11 (PSC4) |
| 12 | Per_mask | Peripheral 12 (PSC5) |
| 13 | Per_mask | Peripheral 13 (SPI modf) |
| 14 | Per_mask | Peripheral 14 (SPI spif) |
| 15 | Per_mask | Peripheral 15 (I2C1) |
| 16 | Per_mask | Peripheral 16 (I2C2) |
| 17 | Per_mask | Peripheral 17 (CAN1) |
| 18 | Per_mask | Peripheral 18 (CAN2) |
| 19 | Per_mask | Reserved |
| 20 | Per_mask | Reserved |
| 21 | Per_mask | Peripheral 21 (XLB Arbiter) |
| 22 | Per_mask | Peripheral 22 (BDLC) |
| 23 | Per_mask | Peripheral 23 (BestComm LocalPlus) |
| 24:31 | — | Reserved |

**Note:**

1. Setting these bits prevents an interrupt being presented to the e300 core pins for the masked sources. Encoded status indications in the ICTL Perstat, MainStat, CritiStat Encoded Register are suppressed, but the binary all status bits (PSa in ICTL Peripheral Interrupt Status All Register) are active as long as the source module is presenting an active input to the Interrupt Controller.

### 7.2.4.2 ICTL Peripheral Priority and HI/LO Select 1 Register

Address MBAR + 0x0504

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Per0_pri | | | | Per1_pri | | | | Per2_pri | | | | Per3_pri | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Per4_pri | | | | Per5_pri | | | | Per6_pri | | | | Per7_pri | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-4. ICTL Peripheral Priority and HI/LO Select 1 Register**

**Table 7-5. CTL Peripheral Priority and HI/LO Select 1 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| — | Per[x]_pri | Priority encoding is done using 4 configuration bits per input source. Each group of 4bits controls the source priority in relation to other peripheral sources. The most significant bit (msb) of each config nibble is called the HI/LO or bank bit.<br>If this bit is high it implies not only a high priority, but causes this interrupt source to assert a HI interrupt condition. Under most circumstances this creates a Critical Interrupt assertion to the e300 core. See Note 1.<br>Peripherals with identical priority settings (either zero or non-zero) are default prioritized with lower peripheral has higher priority. In other words, Per1 has a default priority higher than Per2. |
| 0:3 | Per0_pri | Peripheral 0 = BestComm interrupt (fixed as highest peripheral) |
| 4:7 | Per1_pri | Peripheral 1 = PSC1 interrupt source |
| 8:11 | Per2_pri | Peripheral 2 = PSC2 |
| 12:15 | Per3_pri | Peripheral 3 = PSC3 |
| 16:19 | Per4_pri | Peripheral 4 = PSC6 |
| 20:23 | Per5_pri | Peripheral 5 = Ethernet |
| 24:27 | Per6_pri | Peripheral 6 = USB |
| 28:31 | Per7_pri | Peripheral 7 = ATA |

**Note:**

1. Per0_pri, associated with the BestComm interrupt source, is not programmable and always has the highest peripheral priority and always results in a HI interrupt condition to the Interrupt Controller. These bits are writable and readable, but have no effect on controller operation.

### 7.2.4.3 ICTL Peripheral Priority and HI/LO Select 2 Register

Address MBAR + 0x0508

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Per8_pri | | | | Per9_pri | | | | Per10_pri | | | | Per11_pri | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Per12_pri | | | | Per13_pri | | | | Per14_pri | | | | Per15_pri | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-5. ICTL Peripheral Priority and HI/LO Select 2 Register**

**Table 7-6. ICTL Peripheral Priority and HI/LO Select 2 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| — | Per[x]_pri | Identical to Peripheral_Priority 1 Register, but related to peripheral interrupt sources 8 through 15. All bits are programmable and significant. |
| 0:3 | Per8_pri | Peripheral 8 = PCI Control module |
| 4:7 | Per9_pri | Peripheral 9 = PCI SC Initiator RX |
| 8:11 | Per10_pri | Peripheral 10 = PCI SC Initiator TX |
| 12:15 | Per11_pri | Peripheral 11 = PSC4 |
| 16:19 | Per12_pri | Peripheral 12 = PSC5 |
| 20:23 | Per13_pri | Peripheral 13 = SPI modf |
| 24:27 | Per14_pri | Peripheral 14 = SPI spif |
| 28:31 | Per15_pri | Peripheral 15 = I2C1 |

### 7.2.4.4 ICTL Peripheral Priority and HI/LO Select 3 Register

Address MBAR + 0x050C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Per16_pri | | | | Per17_pri | | | | Per18_pri | | | | Per19_pri | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Per20_pri | | | | Per21_pri | | | | Per22_pri | | | | Per23_pri | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-6. ICTL Peripheral Priority and HI/LO Select 3 Register**

**Table 7-7. ICTL Peripheral Priority and HI/LO Select 3 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| — | Per[x]_pri | Identical to Peripheral_Priority 2 register, but related to peripheral interrupt sources 16–21. All bits are programmable and significant. |
| 0:3 | Per16_pri | Peripheral 16 = I2C2 |
| 4:7 | Per17_pri | Peripheral 17 = CAN1 |
| 8:11 | Per18_pri | Peripheral 18 = CAN2 |
| 12:15 | Per19_pri | Reserved |
| 16:19 | Per20_pri | Reserved |
| 20:23 | Per21_pri | Peripheral 21 = XLB Arbiter |
| 24:27 | Per22_pri | Peripheral 22 = BDLC |
| 28:31 | Per23_pri | Peripheral 23 = BestComm LocalPlus |

### 7.2.4.5 ICTL External Enable and External Types Register

Address MBAR + 0x0510

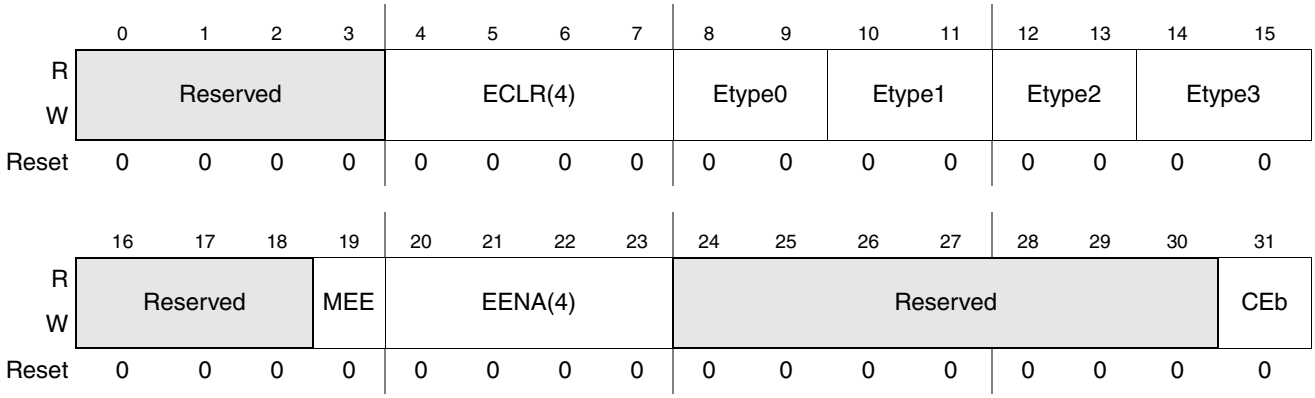



**Figure 7-7. ICTL External Enable and External Types Register**

**Table 7-8. ICTL External Enable and External Types Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| — | ECLR[x] | These bits clear external $\overline{\text{IRQ}}$ interrupt indications. When an $\overline{\text{IRQ}}$ input is configured as an edge-sensitive input, the Interrupt Controller must be notified that the specific interrupt has been serviced. Software must write 1 to the appropriate bit position to clear the interrupt indication. ECLR bits are always read as 0 (i.e., they do not contain status). |
| 4 | ECLR0 | $\overline{\text{IRQ}}$[0], write 1 to clear |
| 5 | ECLR1 | $\overline{\text{IRQ}}$[1], write 1 to clear |
| 6 | ECLR2 | $\overline{\text{IRQ}}$[2], write 1 to clear |
| 7 | ECLR3 | $\overline{\text{IRQ}}$[3], write 1 to clear |
| 8:9 | Etype0 | These bits control how the Interrupt Controller interprets the $\overline{\text{IRQ}}$[0] input pin.<br>00 = Input is level sensitive and active hi<br>01 = Input is edge sensitive, rising edge active”<br>10 = Input is edge sensitive, falling edge active”<br>11 = Input is level sensitive, and active low” |
| 10:11 | Etype1 | Same as above, but for the $\overline{\text{IRQ}}$[1] input pin. |
| 12:13 | Etype2 | Same as above, but for the $\overline{\text{IRQ}}$[2] input pin. |
| 14:15 | Etype3 | Same as above, but for the $\overline{\text{IRQ}}$[3] input pin. |
| 16:18 | — | Reserved—unused bits, writing has no effect, always read as 0. |
| 19 | MEE | Master External Enable—clearing this bit masks all $\overline{\text{IRQ}}$ input transitions (including status indications). |
| — | EENA[x] | Individual enable bits for each $\overline{\text{IRQ}}$ input pin. Setting the associated bit lets the related $\overline{\text{IRQ}}$ pin generate interrupts. In either case, status indications in PSa and CSa (ICTL Peripheral Interrupt Status All Register) are active. |
| 20 | EENA0 | $\overline{\text{IRQ}}$[0] |
| 21 | EENA1 | $\overline{\text{IRQ}}$[1] |

**Table 7-8. ICTL External Enable and External Types Register Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 22 | EENA2 | $\overline{\text{IRQ}}$[2] |
| 23 | EENA3 | $\overline{\text{IRQ}}$[3] |
| 24:30 | — | Reserved |
| 31 | CEb | Critical Enable—a special control bit, which if set, directs critical interrupt sources to the normal e300 core Interrupt pin. This is for system programmer who prefers to handle all interrupts in a single ISR.<br>The status operation remains unchanged, it is necessary to parse Critical Status information prior to Normal Status information to detect critical interrupt sources routed to the normal interrupt pin. |

## 7.2.4.6 ICTL Critical Priority and Main Interrupt Mask Register

Address MBAR + 0x0514

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Crit0_pri | | Crit1_pri | | Crit2_pri | | Crit3_pri | | Reserved | | | | | | | Main_<br>Mask |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Main_Mask | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-8. ICTL Critical Priority and Main Interrupt Mask Register**

**Table 7-9. ICTL Critical Priority and Main Interrupt Mask Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:1 | Crit0_pri | Priority encoding value for Critical Interrupt 0, $\overline{\text{IRQ}}$[0] input pin.<br>There are four Critical Interrupt sources that can be uniquely prioritized (a higher Priority value creates a higher priority, i.e. a value of 3 is the highest priority value). In the case of identical priority value, the lower numbered interrupt source has priority. This makes $\overline{\text{IRQ}}$[0] the highest default priority (being the lowest numbered source). |
| 2:3 | Crit1_pri | Priority encoding value for Slice Timer 0 interrupt source. Hard-wired as critical interrupt source number 1, it has the second highest default priority. |
| 4:5 | Crit2_pri | Priority encoding value for HI_int interrupt source. Hard-wired as critical interrupt source number 2. It is programmable such that any peripheral source can be directed to it, and thus get maximum priority service. |
| 6:7 | Crit3_pri | Priority encoding value for CCS WakeUp source. Hard-wired as critical interrupt source number 3. |
| 8:14 | — | Reserved |

**Table 7-9. ICTL Critical Priority and Main Interrupt Mask Register Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| — | Main_Mask[x] | To mask/accept individual main interrupt sources (as opposed to peripheral or critical interrupt sources). This masking is in addition to interrupt enables, which may exist in each source module.<br>0 Default. Accept interrupt from source module.<br>1 Ignore interrupt from source module.<br><br>Take care if masking LO_int, which is a collection of multiple Peripheral sources in a single presentation. Masking LO_int essentially prevents any LO Peripheral from generating an interrupt, even when those interrupts are enabled (i.e., unmasked) in Per_Mask, Reg0. **Important**—See Note 1. |
| 15 | Main_Mask0 | Slice Timer 1, which is hardwired to SMI interrupt output. See Note 2. |
| — | — | Interrupt sources below are bank/priority programmable (in Reg6 and Reg7). |
| 16 | Main_Mask1 | $\overline{IRQ}$[1] ($\overline{IRQ}$[1] input pin interrupt) |
| 17 | Main_Mask2 | $\overline{IRQ}$[2] ($\overline{IRQ}$[2] input pin interrupt) |
| 18 | Main_Mask3 | $\overline{IRQ}$[3] ($\overline{IRQ}$[3] input pin interrupt) |
| 19 | Main_Mask4 | LO_int (source programmable from Peripheral ints) |
| 20 | Main_Mask5 | RTC_pint (Real time clock, periodic interrupt) |
| 21 | Main_Mask6 | RTC_sint (Real time clock, stopwatch and alarm interrupt) |
| 22 | Main_Mask7 | GPIO_std (collected GPIO interrupts, non-WakeUp) |
| 23 | Main_Mask8 | GPIO_wkup (collected WakeUp interrupts) |
| 24 | Main_Mask9 | TMR0 (internal Timer resource) |
| 25 | Main_Mask10 | TMR1 (internal Timer resource) |
| 26 | Main_Mask11 | TMR2 (internal Timer resource) |
| 27 | Main_Mask12 | TMR3 (internal Timer resource) |
| 28 | Main_Mask13 | TMR4 (internal Timer resource) |
| 29 | Main_Mask14 | TMR5 (internal Timer resource) |
| 30 | Main_Mask15 | TMR6 (internal Timer resource) |
| 31 | Main_Mask16 | TMR7 (internal Timer resource) |

**Note:**

1. Setting these bits prevents an interrupt being presented to the masked sources e300 core pins. Encoded status indications (MSe in Reg9) are therefore suppressed, but the binary all status bits (MSa in RegB) are active as long as the source module is presenting an active input to the Interrupt Controller. Masking $\overline{IRQ}$[1:3], is redundant with External ENA bits in Reg4, but both masks are applied.
2. Slice Timer 1 is hard-coded and neither bank nor priority adjustable.

### 7.2.4.7 ICTL Main Interrupt Priority and INT/SMI Select 1 Register

Address MBAR + 0x0518

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Main1_pri | | | | Main2_pri | | | | Main3_pri | | | | Main4_pri | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Main5_pri | | | | Main6_pri | | | | Main7_pri | | | | Main8_pri | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-9. ICTL Main Interrupt Priority and INT/SMI Select 1 Register**

**Table 7-10. ICTL Main Interrupt Priority and INT/SMI Select 1 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | Main1_pri | Main interrupt source 1 ($\overline{\text{IRQ}}$[1]) priority encoding value.<br>All four bits are used to set a priority value (higher value equals higher priority). MSbit is also used as a bank bit to direct this interrupt source to SMI interrupt output (if bank = 1), or to normal INT interrupt output (if bank = 0).<br>For interrupt sources set at the same priority value, default priority is the lower numbered interrupt has higher priority. This means main source 1 has a higher default priority than main source 2. See Note 1. |
| 4:7 | Main2_pri | Main interrupt source 2 ($\overline{\text{IRQ}}$[2] input pin) priority encoding value. |
| 8:11 | Main3_pri | Main interrupt source 3 ($\overline{\text{IRQ}}$[3] input pin) priority encoding value. |
| 12:15 | Main4_pri | Main interrupt source 4 (LO_int) priority encoding value. LO_int is a collection of any Peripheral Interrupts directed to this interrupt source. Peripheral interrupts sources are directed to either LO_int, or to the critical interrupt source HI_int. |
| 16:19 | Main5_pri | Main interrupt source 5 (RTC_periodic) priority encoding value. |
| 20:23 | Main6_pri | Main interrupt source 6 (RTC_stopwatch and RTC_alarm) priority encoding value. |
| 24:27 | Main7_pri | Main interrupt source 7 (GPIO_std) priority encoding value. GPIO_std is a collection of all simple interrupt GPIO pins enabled for Interrupt operation. |
| 28:31 | Main8_pri | Main Interrupt source 8 (GPIO_wkup) priority encoding value.<br>GPIO_wkup is a collection of all enabled WakeUp capable GPIO sources. WakeUp interrupt sources also operate in normal powered-up modes so all GPIO interrupt sources are represented by main interrupt sources 7 and 8 (also see Timer GPIOs in Reg7). |

**Note:**

1. Main source 0 (Slice Timer 1) is not listed, it is fixed as both the highest priority main interrupt and to generate an SMI interrupt output only.

### 7.2.4.8 ICTL Main Interrupt Priority and INT/SMI Select 2 Register

Address MBAR + 0x051C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Main9_pri | | | | Main10_pri | | | | Main11_pri | | | | Main12_pri | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Main13_pri | | | | Main14_pri | | | | Main15_pri | | | | Main16_pri | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-10. ICTL Main Interrupt Priority and INT/SMI Select 2 Register**

**Table 7-11. ICTL Main Interrupt Priority and INT/SMI Select 2 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | Main9_pri | Main interrupt source 9 (TMR0) priority encoding value.<br>All 4bits are used to set a priority value (higher value equals higher priority). The msb is also used as a bank bit to direct this interrupt source to SMI interrupt output (if bank = 1), or to normal INT interrupt output (if bank = 0).<br>For interrupt sources set at the same priority value, default priority is the lower numbered interrupt has higher priority. This means main source 9 has a higher default priority than main source 10.<br>Timer 0 is one of eight internal timer resources that can be configured as input capture, output compare, or PWM output. As such, there is an I/O pin associated with each timer. The timer can use this pin as GPIO, in which case the internal timer function becomes available. These eight timers complete the MPC5200B GPIO structure. All potential GPIO interrupt sources are represented by main sources 7, 8, and 9–16. |
| 4:7 | Main10_pri | Main interrupt source 10 (TMR1) priority encoding value. |
| 8:11 | Main11_pri | Main interrupt source 11 (TMR2) priority encoding value. |
| 12:15 | Main12_pri | Main interrupt source 12 (TMR3) priority encoding value. |
| 16:19 | Main13_pri | Main interrupt source 13 (TMR4) priority encoding value. |
| 20:23 | Main14_pri | Main interrupt source 14 (TMR5) priority encoding value. |
| 24:27 | Main15_pri | Main interrupt source 15 (TMR6) priority encoding value. See Note 1. |
| 28:31 | Main16_pri | Main interrupt source 16 (TMR7) priority encoding value. See Note 1. |

**Note:**

1. This timer has WakeUp functionality and therefore can provide a WakeUp interrupt source.

### 7.2.4.9 ICTL Perstat, MainStat, CritStat Encoded Register

Address MBAR + 0x0524

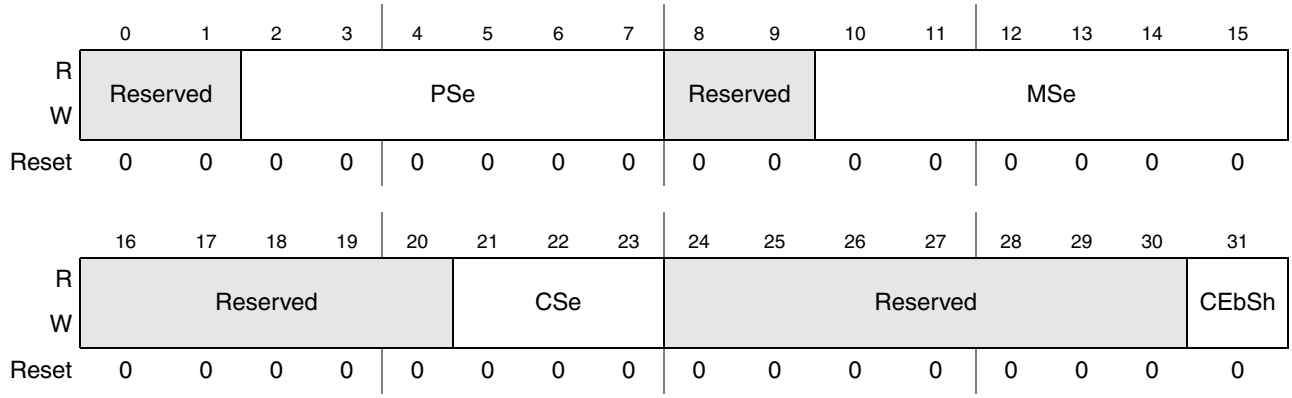



**Figure 7-11. ICTL PerStat, MainStat, CritStat Encoded Register**

**Table 7-12. ICTL PerStat, MainStat, CritStat Encoded Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2:7 | PSe | Peripheral Status Encoded—makes a singular indication of the current peripheral interrupt (6bits indicating 1 of 24 possible peripheral interrupts).<br>The msb operates as a flag bit and is set if any peripheral interrupt is currently being presented by the Interrupt Controller (e.g., if peripheral interrupt source 0 is current, then this register reads as 0x20). Normally it would not be necessary to clear this status register since all peripheral interrupt sources are level sensitive.<br>Once an interrupt source negates at the input of the controller, the new input condition is re-evaluated without software intervention. However, if ISR does not clear the interrupt source (at the source module), then the controller is locked on the current interrupt and cannot re-evaluate the input condition (possibly to detect the presence of a higher priority interrupt). Therefore, ISR can force a re-evaluation of the input condition by writing 1 to the msb of PSe. This sticky-bit clear operation is optional and can be used at the discretion of the ISR writer.<br>The encoded value cross-reference to a specific source is described in ICTL Peripheral Interrupt Mask Register and re-stated in ICTL Peripheral Interrupt Status All Register. In all cases, the peripheral status encoded value converts to a single source module (i.e., no additional status parsing is required at the Interrupt Controller). |
| 8:9 | — | Reserved |
| 10:15 | MSe | Main Status Encoded—makes a singular indication of the current main interrupt (6 bits indicating 1 of 17 possible main interrupts).<br>The msb operates as a flag bit, as described above. The msb can also be written to 1 to force a re-evaluation of the main interrupt sources.<br>The cross-reference of the encoded value to a particular source is described in Reg5 (main mask) and re-stated in ICTL Main Status All Register.<br>All MSe values convert to a single source module, EXCEPT Main source 4 (LO_int), which indicates a peripheral source is active. In this case it is necessary to parse the PSe to determine which peripheral source is active. See Note 1. |
| 16:20 | — | Reserved |

**Table 7-12. ICTL PerStat, MainStat, CritStat Encoded Register Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 21:23 | CSe | Critical Status Encoded—makes a singular indication of the current critical interrupt (3bits indicating 1 of 4 possible interrupts).<br>The msb operates as a Flag bit, as described above. This msb can also be written to 1 to force a re-evaluation of the critical interrupt sources.<br>00 $\overline{\text{IRQ}}$ input pin is the source. See Note 2.<br>01 Slice Timer 0 is the source.<br>10 HI_int is the source. See Note 3.<br>11 CCS module is the source. WakeUp from deep-sleep. See Note 4. |
| 24:30 | — | Reserved |
| 31 | CEbSh | Critical Enable bar Shadow bit—this is a special bit that shadows the setting programmed into ICTL External Enable and External Types Register. This bit indicates whether Critical interrupt sources have or have not been directed to the normal INT e300 core pin.<br>If Critical interrupts are directed to INT (CEbSh = 1), to detect higher priority interrupt sources, INT ISR must always parse the CSe prior to MSe or PSe. All other processing remains the same.<br>This shadow bit is provided here so a single read to this register can obtain all necessary information to make the interrupt source determination. |

**Note:**

1. For Main sources 1, 2, and 3 that represent $\overline{\text{IRQ}}$[1:3] respectively, if the $\overline{\text{IRQ}}$ pin is set as edge sensitive, it is REQUIRED that the MSe flag bit be cleared (i.e., written to 1) or the appropriate ECLR bit in ICTL External Enable and External Types Register be set to clear this interrupt indication. Only one method should be used, not both (this limit is only true for multiple edge-sensitive $\overline{\text{IRQ}}$ inputs).
2. For $\overline{\text{IRQ}}$[0] set as edge sensitive, it is REQUIRED that either the CSe flag bit be cleared (i.e., written to 1) or the ECLR[0] bit in ICTL External Enable and External Types Register be set to clear this interrupt indication. You can do both if desired, and you can do it regardless of the $\overline{\text{IRQ}}$[0] interrupt type.
3. This indicates a peripheral source programmed for HI bank priority is the source. It is necessary to parse the PSe value to determine the peripheral source module.
4. For recovery from deep-sleep mode, it is necessary to acknowledge this WakeUp interrupt by writing 1 to the msb of this field (CSe). Only then does the CCS module release it's power-down internal signal and let MPC5200B operate normally.

## 7.2.4.10 ICTL Critical Interrupt Status All Register

Address MBAR + 0x0528

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | CSa | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-12. ICTL Critical Interrupt Status All Register**

**Table 7-13. ICTL Critical Interrupt Status All Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| — | CSa[x] | Critical Interrupt Status All—Indicates all pending interrupts, including the currently active interrupt (if any). CSa is binary, showing each active interrupt input in its corresponding bit position. See Note 1.<br>Number in parenthesis indicates equivalent encoded value in CSe, ICTL PerStat, MainStat, CritStat Encoded Register. |
| 4 | CSa0 | indicates $\overline{\text{IRQ}}$[0] interrupt |
| 5 | CSa1 | Slice Timer 0 interrupt |
| 6 | CSa2 | HI_int interrupt |
| 7 | CSa3 | WakeUp from deep-sleep mode (CCS) interrupt |
| 8:31 | — | Reserved |

**Note:**

1. No direct mask register is defined for critical interrupts. However, $\overline{\text{IRQ}}$[0] can be masked by the MEE bit in Reg4, in which case CSa status does not occur. If only the EENA[0] bit in ICTL External Enable and External Types Register is cleared, then CSa status occurs, but controller does not assert a e300 core interrupt.

### 7.2.4.11 ICTL Main Interrupt Status All Register

Address MBAR + 0x052C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | MSa |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | MSa | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-13. ICTL Main Interrupt Status All Register**

**Table 7-14. ICTL Main Interrupt Status All Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:14 | — | Reserved |
| — | MSa[x] | Main Interrupt Status All. Indicates all pending interrupts. Is binary, showing each active interrupt in its corresponding bit position. See Note 1.<br>Number in parenthesis indicates equivalent encoded value in MSe, Reg9. |
| 15 | MSa0 | Slice_Timer 1 (SMI interrupt only) |
| 16 | MSa1 | $\overline{\text{IRQ}}$[1] input pin |
| 17 | MSa2 | $\overline{\text{IRQ}}$[2] input pin |
| 18 | MSa3 | $\overline{\text{IRQ}}$[3] input pin |
| 19 | MSa4 | LO_int (some Peripheral source) |
| 20 | MSa5 | RTC_periodic interrupt |
| 21 | MSa6 | RTC_stopwatch interrupt |
| 22 | MSa7 | GPIO std interrupt |
| 23 | MSa8 | GPIO WakeUp interrupt |
| 24 | MSa9 | TMR0 interrupt |
| 25 | MSa10 | TMR1 interrupt |
| 26 | MSa11 | TMR2 interrupt |
| 27 | MSa12 | TMR3 interrupt |
| 28 | MSa13 | TMR4 interrupt |
| 29 | MSa14 | TMR5 interrupt |
| 30 | MSa15 | TMR6 interrupt |
| 31 | MSa16 | TMR7 interrupt |

**Note:**

1. All main interrupt sources are directly maskable in Main_Mask, ICTL Critical Priority and Main Interrupt Mask Register. If masked in Main_Mask, status information still shows in MSa. However, if interrupt is not enabled at the source module (i.e., in source module registers) the Interrupt Controller cannot observe or record status information for that interrupt.

### 7.2.4.12 ICTL Peripheral Interrupt Status All Register

Address MBAR + 0x0530

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | PSa | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | PSa | | | | | | | | | | | | | Reserved | | PSa21 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-14. ICTL Peripheral Interrupt Status All Register**

**Table 7-15. ICTL Peripheral Interrupt Status All Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | — | Reserved |
| — | PSa[x] | Peripheral Interrupt Status All. Indicates all pending interrupts. Is binary, showing each active interrupt in its corresponding bit position. See Note 1.<br>Number in parenthesis indicates equivalent encoded value in PSe, ICTL PerStat, MainStat, CritStat Encoded Register. |
| 8 | PSa23 | BestComm LocalPlus |
| 9 | PSa22 | BDLC |
| 10 | PSa0 | BestComm interrupt source |
| 11 | PSa1 | PSC1 |
| 12 | PSa2 | PSC2 |
| 13 | PSa3 | PSC3 |
| 14 | PSa4 | PSC6 |
| 15 | PSa5 | Ethernet |
| 16 | PSa6 | USB |
| 17 | PSa7 | ATA |
| 18 | PSa8 | PCI Control module |
| 19 | PSa9 | PCI SC Initiator Rx |
| 20 | PSa10 | PCI SC Initiator Tx |
| 21 | PSa11 | PSC4 |
| 22 | PSa12 | PSC5 |
| 23 | PSa13 | SPI modf |
| 24 | PSa14 | SPI spif |
| 25 | PSa15 | $I^2C1$ |

**Table 7-15. ICTL Peripheral Interrupt Status All Register Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 26 | PSa16 | $I^2C2$ |
| 27 | PSa17 | CAN1 |
| 28 | PSa18 | CAN2 |
| 29:30 | — | Reserved |
| 31 | PSa21 | XLB Arbiter |

**Note:**

1. These interrupts are directly maskable by ICTL Peripheral Interrupt Mask Register. However, PSa status occurs regardless of Per_Mask setting, as long as the source module interrupt is enabled in the source module registers.

## 7.2.4.13 ICTL Peripheral Interrupt Status All Register

Address MBAR + 0x0538

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | BE1 | BE0 | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-15. ICTL Bus Error Status Register**

**Table 7-16. ICTL Bus Error Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:5 | — | Reserved |
| 6 | BE1 | Bus Error 1—Indicates write attempt to read-only register, clear with a write to 1. |
| 7 | BE2 | Bus Error 0—Indicates access to unimplemented register, clear with a write to 1. |
| 8:31 | — | Reserved |

### 7.2.4.14 ICTL Main Interrupt Emulation All Register

Address MBAR + 0x0540

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | MEa |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | MEa | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-16. ICTL Main Interrupt Emulation All Register**

**Table 7-17. ICTL Main Interrupt Emulation All Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:14 | — | Reserved |
| — | MEa[x] | This register provides a way for software to emulate the assertion of a particular Main/SIU interrupt. The actual interrupt is the OR or the normal interrupt source and each of these test register bits. The order is exactly the same as the MSa in<br>ICTL Main Interrupt Status All Register.<br>The MEa[x] bits ARE masked by the Main_Mask setting, so they operate as<br>much as possible as the real interrupt source. Even the IRQ sources, which may be programmed as edge sensitive, will react just like the pin when emulated here with test bit assertion/negation. One exception is LO-int, which if asserted here, will NOT create a corresponding Peripheral Status indication.<br>If relying on MEa[x] assertion/negation to emulate and test an ISR routine it is<br>important to disable all source modules so that real source interrupts will not disturb<br>the test generated interrupt. |
| 15 | MEa0 | Slice_Timer 1 (SMI interrupt only) |
| 16 | MEa1 | $\overline{\text{IRQ}}$[1] input pin |
| 17 | MEa2 | $\overline{\text{IRQ}}$[2] input pin |
| 18 | MEa3 | $\overline{\text{IRQ}}$[3] input pin |
| 19 | MEa4 | LO_int (some Peripheral source) |
| 20 | MEa5 | RTC_periodic interrupt |
| 21 | MEa6 | RTC_stopwatch interrupt |
| 22 | MEa7 | GPIO std interrupt |
| 23 | MEa8 | GPIO WakeUp interrupt |
| 24 | MEa9 | TMR0 interrupt |
| 25 | MEa10 | TMR1 interrupt |
| 26 | MEa11 | TMR2 interrupt |
| 27 | MEa12 | TMR3 interrupt |
| 28 | MEa13 | TMR4 interrupt |
| 29 | MEa14 | TMR5 interrupt |
| 30 | MEa15 | TMR6 interrupt |
| 31 | MEa16 | TMR7 interrupt |

### 7.2.4.15 ICTL Peripheral Interrupt Emulation All Register

Address MBAR + 0x0544

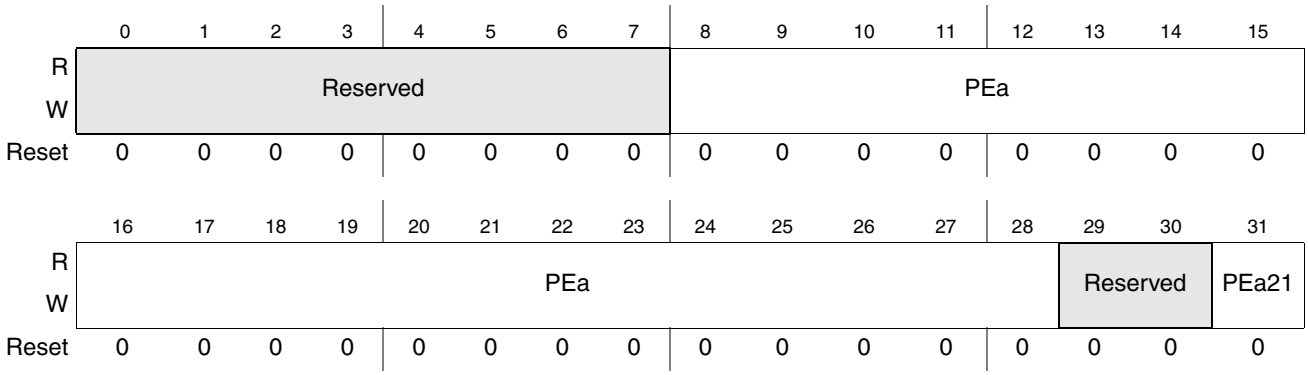



**Figure 7-17. ICTL Peripheral Interrupt Emulation All Register**

**Table 7-18. ICTL Peripheral Interrupt Emulation All Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | — | Reserved |
| — | PEa[x] | This register provides a way for software to emulate the assertion of a particular Peripheral interrupt. The actual interrupt is the OR or the normal interrupt source and each of these test register bits. The order is exactly the same as the PSa in ICTL Peripheral Interrupt Status All Register. The PEa[x] bits ARE masked by the Per_Mask setting, so they operate as much as possible as the real interrupt source. Test assertion of a peripheral source will cause HI-int or LO-int indications which will be reflected in the Main or Critical status registers. If relying on PEa[x] assertion/negation to emulate and test an ISR routine it is important to disable all source modules so that real source interrupts will not disturb the test generated interrupt. |
| 8 | PEa23 | BestComm LocalPlus |
| 9 | PEa22 | BDLC |
| 10 | PEa0 | BestComm interrupt source |
| 11 | PEa1 | PSC1 |
| 12 | PEa2 | PSC2 |
| 13 | PEa3 | PSC3 |
| 14 | PEa4 | PSC6 |
| 15 | PEa5 | Ethernet |
| 16 | PEa6 | USB |
| 17 | PEa7 | ATA |
| 18 | PEa8 | PCI Control module |
| 19 | PEa9 | PCI SC Initiator Rx |
| 20 | PEa10 | PCI SC Initiator Tx |
| 21 | PEa11 | PSC4 |
| 22 | PEa12 | PSC5 |
| 23 | PEa13 | SPI modf |
| 24 | PEa14 | SPI spif |
| 25 | PEa15 | $I^2C1$ |

**Table 7-18. ICTL Peripheral Interrupt Emulation All Register Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 26 | PEa16 | $I^2C2$ |
| 27 | PEa17 | CAN1 |
| 28 | PEa18 | CAN2 |
| 29:30 | — | Reserved |
| 31 | PEa21 | XLB Arbiter |

## 7.2.4.16 ICTL IRQ Interrupt Emulation All Register

Address MBAR + 0x0548

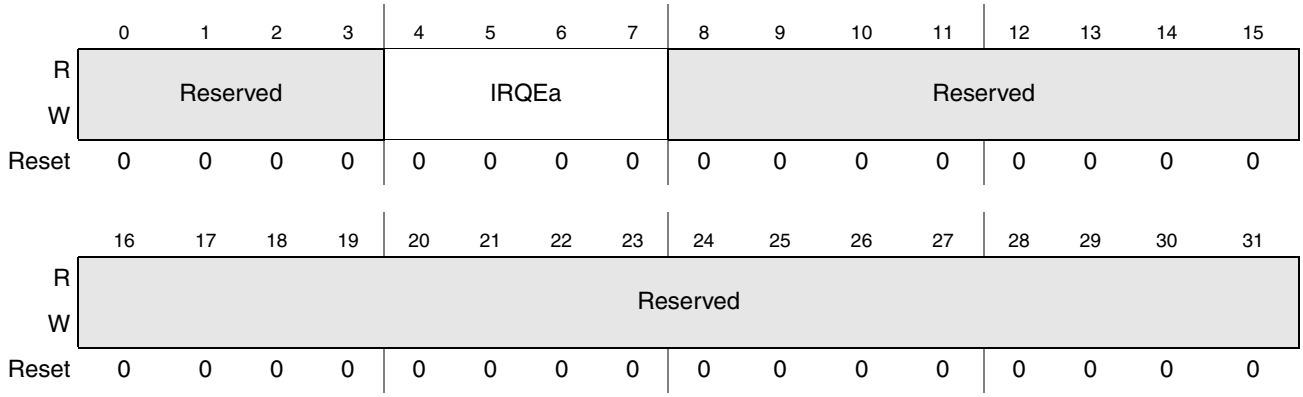



**Figure 7-18. ICTL IRQ Interrupt Emulation All Register**

**Table 7-19. ICTL IRQ Interrupt Emulation All Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| — | IRQEa[x] | This register provides a way for software to emulate the assertion of a particular external interrupt pin. The actual interrupt is the OR of the normal interrupt source and each of these IRQEa[x] bits. This register represents the four IRQ inputs. This register is redundant with IICTL Main Interrupt Emulation All Register for IRQ1-3 but is the only source to emulate IRQ0. It provides a single register with which to test and develop an ISR for the external interrupt sources. Each bit operates as if it were the pin itself, i.e. edge sensitive operation would require multiple test writes to create the emulation of a pulsing input. See Note 1 |
| 4 | IRQEa0 | $\overline{IRQ}$[0] input pin emulation |
| 5 | IRQEa1 | $\overline{IRQ}$[1] input pin emulation |
| 6 | IRQEa2 | $\overline{IRQ}$[2] input pin emulation |
| 7 | IRQEa3 | $\overline{IRQ}$[3] input pin emulation |
| 8:31 | — | Reserved |

**Note:**

1. The emulation is only possible if the IRQ pins are externally pulled down. Otherwise the OR between the external pin values and the IRQEa[x] bits is whole the time one.

## 7.3 General Purpose I/O (GPIO)

There are a total of 56 possible GPIO pins on the MPC5200B. Virtually all of these pins are shared with alternate hardware functions. Therefore, GPIO availability is entirely dependant on the peripheral set a particular application requires.

There are 5 basic types of GPIO pins, controlled by separate register groupings, and in some cases, different register modules:

- 24 “Simple” GPIO, controlled in the standard GPIO register module.
- 8 “Output Only” GPIO, controlled in the standard GPIO register module.
- 8 “Interrupt” GPIO, controlled in the standard GPIO register module.
- 8 “Wakeup” GPIO, controlled in the WakeUp GPIO register module.
- 8 “Timer” GPIO, controlled in the General Purpose Timer register module.

There is a hierarchy of GPIO functionality. Higher function GPIO can be programmed to operate at any lower functional level. The hierarchy, from lowest to highest, is as follows:

- **Output Only**—As the name suggests, these GPIO cannot be programmed as Inputs. As outputs, they can be programmed to emulate an Open-Drain output.
- **Simple**—Same as Output Only, but with additional capability to be programmed as inputs, with a corresponding Input Value register that can be read by software.
- **Interrupt**—Same as Simple, but with additional capability of generating an Interrupt to the CPU during normal powered-up mode. The Interrupt Type can be programmed as edge (any/rising/falling/2nd edge) sensitive. These GPIO are sometimes referred to as “Simple Interrupt”.
- **Wakeup**—Same as Interrupt, but with additional capability of generating an Interrupt during Deep Sleep mode. Includes Interrupt Type registers and has an extra enable bit to distinguish between Simple Interrupt or WakeUp Interrupt operation.
- **Timer GPIO**—Operates with Simple GPIO capability, but can generate CPU Interrupts if configured as Input Capture timer mode. These Timer GPIO have special capabilities and limitations, which are described in Section 7.4, “General Purpose Timers (GPT)”. Timer GPIO does not fit cleanly into the GPIO functional hierarchy concept, and should therefore be considered as a unique GPIO function.

GPIO functionality is available on an I/O pin only if the pin is enabled for GPIO usage in the Section 7.3.2.1.1, “GPS Port Configuration Register”. The GPIOPCR register controls the top level pin-muxing, which sets an I/O pin’s usage between some hardware function(s) and GPIO. If the pin is available for GPIO, the associated GPIO registers must be enabled and configured by software to complete the GPIO operation for that specific pin. If a Timer GPIO is consumed by an alternate hardware function, it is still available to work as an internal General Purpose Timer (GPT).

Simple GPIO are controlled by a group of registers in the Standard GPIO module. They are organized in relation to the multi-function hardware port groupings. For example, you will see a GPIO field named PSC1 (4 bits) that corresponds to the 4 Simple GPIO available on the PSC1 port group. There is also a WakeUp GPIO on the PSC1 port. However, this pin, as GPIO, would be controlled by a separate register

in the Wakeup GPIO module. Even though the pins are physically scattered throughout the multi-function port groups, register control groupings exist for the:

- 8 Wakeup GPIO pins
- 8 Interrupt GPIO pins, and
- 8 Output-Only GPIO pins.

Only Simple GPIO register groupings correspond to the physical pin groupings.

Table 7-20 lists all 56 GPIO pins.

**Table 7-20. GPIO Pin List (Sheet 1 of 2)**

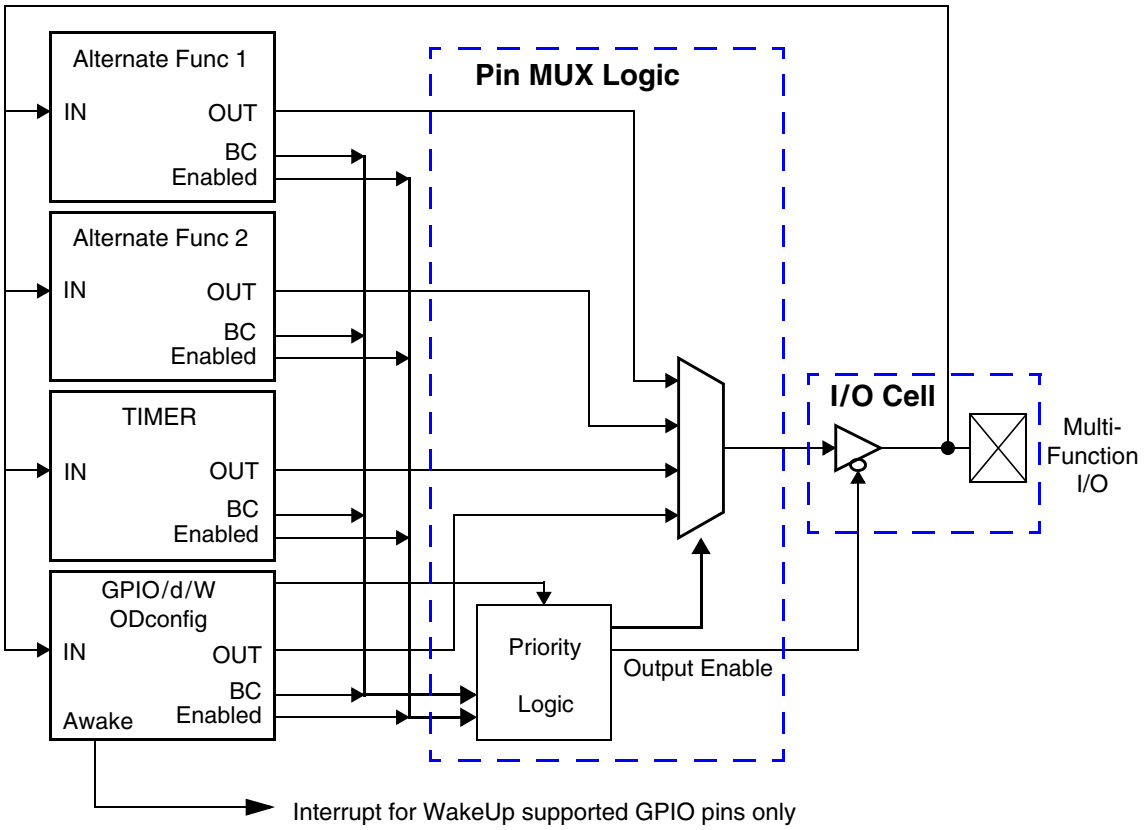
| GPIO PIN | Alternate Functionality | Interrupt | WakeUp |
|---|---|---|---|
| TIMER_0 | Timer_GPIO/ATA/CAN2 | Only as Timer | No |
| TIMER_1 | Timer_GPIO/ATA/CAN2 | Only as Timer | No |
| TIMER_2 | Timer_GPIO/SPI | Only as Timer | No |
| TIMER_3 | Timer_GPIO/SPI | Only as Timer | No |
| TIMER_4 | Timer_GPIO/SPI | Only as Timer | No |
| TIMER_5 | Timer_GPIO/SPI | Only as Timer | No |
| TIMER_6 | Timer_GPIO | Only as Timer | Yes (Timer IC) |
| TIMER_7 | Timer_GPIO | Only as Timer | Yes (Timer IC) |
| PSC1_0 | UART1/AC971/CODEC1 | No | No |
| PSC1_1 | UART1/AC971/CODEC1 | No | No |
| PSC1_2 | UART1/AC971 | No | No |
| PSC1_3 | UART1/AC971/CODEC1 | No | No |
| PSC1_4 | UART1/AC971/CODEC1 | Yes | Yes |
| PSC2_0 | UART2/AC972/CODEC2/CAN1 | No | No |
| PSC2_1 | UART2/AC972/CODEC2/CAN1 | No | No |
| PSC2_2 | UART2/AC972/CAN2 | No | No |
| PSC2_3 | UART2/AC972/CODEC2/CAN2 | No | No |
| GPIO_WKUP_1(PSC2_4) | UART2/AC972/CODEC2 | Yes | Yes |
| GPIO_PSC3_0 | USB2/CODEC3/UART3 | No | No |
| GPIO_PSC3_1 | USB2/CODEC3/UART3 | No | No |
| GPIO_PSC3_2 | USB2/CODEC3/UART3 | No | No |
| GPIO_PSC3_3 | USB2/CODEC3/UART3 | No | No |
| GPIO_SINT_0(PSC3_4) | USB2/UART3 | Yes | No |
| GPIO_SINT_1(PSC3_5) | USB2 | Yes | No |
| GPIO_PSC3_6 | USB2/SPI | No | No |
| GPIO_PSC3_7 | USB2/SPI | No | No |

**Table 7-20. GPIO Pin List (Sheet 2 of 2)**

| GPIO PIN | Alternate Functionality | Interrupt | WakeUp |
|---|---|---|---|
| GPIO_SINT_2(PSC3_8) | USB2/SPI | Yes | No |
| GPIO_WKUP_2(PSC3_9) | USB2/SPI | Yes | Yes |
| GPIO_USB_0 | USB1 (OE) | No | No |
| GPIO_USB_1 | USB1 (PORTPWR)/UART5 (TXD) | No | No |
| GPIO_USB_2 | USB1 (SPEED)/UART5 (RTS) | No | No |
| GPIO_USB_3 | USB1 (SUSPEND)/UART5 (CTS) | No | No |
| GPIO_SINT_3(USB) | USB1 (OvrCrnt) | Yes | No |
| GPIO_ETHO_0(out only) | Ethernet | No | No |
| GPIO_ETHO_1(out only) | Ethernet/UART5 | No | No |
| GPIO_ETHO_2(out only) | Ethernet/USB2/UART5 | No | No |
| GPIO_ETHO_3(out only) | Ethernet/USB2/UART4 | No | No |
| GPIO_ETHO_4(out only) | Ethernet/USB2/J1850 | No | No |
| GPIO_ETHO_5(out only) | Ethernet/USB2/UART4 | No | No |
| GPIO_ETHO_6(out only) | Ethernet/USB2 | No | No |
| GPIO_ETHO_7(out only) | Ethernet/USB2 | No | No |
| GPIO_ETHI_0 | Ethernet/UART5 | No | No |
| GPIO_ETHI_1 | Ethernet/UART5 | No | No |
| GPIO_ETHI_2 | Ethernet | No | No |
| GPIO_ETHI_3 | Ethernet | No | No |
| GPIO_SINT_4(ETH) | Ethernet/USB2/J1850 | Yes | No |
| GPIO_SINT_5(ETH) | Ethernet/USB2/UART4 | Yes | No |
| GPIO_SINT_6(ETH) | Ethernet/USB2/UART4 | Yes | No |
| GPIO_SINT_7(ETH) | Ethernet/USB2/UART4 | Yes | No |
| GPIO_WKUP_3(ETH) | Ethernet | Yes | Yes |
| GPIO_IRDA_0 | IRDA/UART6/Codec6 | No | No |
| GPIO_IRDA_1 | IRDA(and/or USB)/UART6/Codec6 | No | No |
| GPIO_WKUP_4(IRDA) | IRDA/UART6/Codec6 | Yes | Yes |
| GPIO_WKUP_5(IRDA) | IRDA/UART6/Codec6 | Yes | Yes |
| GPIO_WKUP_6 | Dedicated GPIO Pin/SDRAM CS1 | Yes | Yes |
| GPIO_WKUP_7 | Dedicated GPIO Pin/LocalPlus Most/Graphics mode TSIZ1 | Yes | Yes |

### 7.3.1 GPIO Pin Multiplexing

Figure 7-19 shows the GPIO/Generic MUX cell.




**Note:**

1. Open-Drain Emulation is supported on the GPIO function.
2. Pin MUX Logic is controlled by the Port Configuration Register and supersedes any individual GPIO register programming.

**Figure 7-19. GPIO/Generic MUX Cell**

#### 7.3.1.1 PSC1 (UART1/AC97/CODEC1)

The PSC1 port has 5 pins with hardware support for:

- CODEC
- UART (4 pins consumed)
- UARTe (expanded with carrier detect input–5 pins consumed)
- AC97

Unused pins can serve as simple GPIOs, with one available as a WakeUp input. For use as AC97, this WakeUp GPIO becomes available. A special mode is available in which the CD input for UART use can be unused. This makes a WakeUp GPIO available on this port. CODEC usage makes one simple GPIO available. Use of this port for AC97 consumes all 5 pins and leaves no GPIO available.

Refer to the port-mapping illustrations Figure 2-4.

#### 7.3.1.2 PSC2 (CAN1/2/UART2/AC97/CODEC2)

The PSC2 port has 5 pins with hardware support for:

- CAN
- CODEC
- UART (4 pins consumed)
- UARTe (expanded with carrier detect input–5 pins consumed)
- AC97

Unused pins can serve as simple GPIOs, with one available as a WakeUp input. For use as AC97, this WakeUp GPIO becomes available. A special mode is available in which the CD input for UART use can be unused. This makes a WakeUp GPIO available on this port. CODEC usage makes one simple GPIO available. Use of this port for AC97 consumes all 5 pins and leaves no GPIO available.

Refer to the port-mapping illustrations Figure 2-5.

#### 7.3.1.3 PSC3 (USB2/CODEC3/SPI/UART3)

The PSC3 port has 10pins with hardware support for:

- CODEC
- Expanded UART (5 pins consumed)
- SPI (4 pins consumed)
- USB secondary port (10 pins consumed)

SPI can simultaneously exist, with no pins leftover for GPIO. Similarly, CODEC or UART can exist with SPI leaving no leftover pins. Unless, CD input on UART is designated unused, in which case a WakeUp GPIO becomes available. Any unused pins are available for related RS232 GPIO functionality.

Refer to the port-mapping illustrations Figure 2-6.

#### 7.3.1.4 USB1/RST_CONFIG

This is a 10-bit port dedicated to primary USB. GPIO becomes available **only** if the USB function is not used. When this occurs, the following GPIO becomes available:

- 4 Simple GPIO
- 1 Interrupt GPIO

Other pins on this port serve as Reset Configuration inputs.

### 7.3.1.5 Ethernet/USB2/UART4/5/J1850/RST_CONFIG

This port consists of 8 output data pins and 10 control pins (in ethernet mode). For GPIO grouping these are the EthO and EthI ports, respectively. The output-only pins (EthO) are also used for input reset configuration data, therefore these pins must act as output only in all other cases. No peripheral is allowed to overdrive the reset configuration pull-up/pull-down settings. The 8 GPIOs on the EthO port are therefore output-only, and only available if the pin is otherwise unused (beyond reset config).

**NOTE**

The ethernet pin, MDIO, is actually an I/O. However, there should be no danger of an external chip driving this pin during power-up.

This port is configured such that 7-wire Ethernet and a secondary USB port can exist simultaneously. This configuration makes available 1 GPIO WakeUp pin.

Full Ethernet consumes all 18 pins, unless the optional MDIO and MDC pins are specified as unused. In this case, 2 Output Only GPIO are available.

Meanwhile, there are other cases because many pins can be used for UART, J1850. Please Refer to the port-mapping illustrations for details.

USB stand-alone usage leaves available:

- 2 Output Only GPIO
- 4 Simple GPIO
- 1 WakeUp GPIO

7-wire Ethernet stand-alone leaves available:

- 6 Output Only GPIO
- 4 Interrupt GPIO
- 1 WakeUp GPIO

1850 stand-alone leaves available:

- 7 Output Only GPIO
- 4 Simple GPIO
- 3 Interrupt GPIO
- 1 WakeUp GPIO

Total GPIO available on this port is:

- 8 Output Only GPIO
- 4 Simple GPIO
- 4 Interrupt GPIO
- 1 WakeUp GPIO

### 7.3.1.6 PSC6

The PSC6 port has 4 pins, which includes:

- 2 Simple GPIO
- 2 WakeUp GPIO

Hardware functions available are:

- IRDA
  - 3 pins with clock input
  - 2 pins with internal clock
- UART (4 pins)
- Codec (4 pins)

The IRDA clock pin can be used as a Input USB clock and is separately programmable for this use.

- If unused, the IRDA Receive pins are available as WakeUp GPIO.
- If unused, the IRDA Transmit pin and the Clock pin are available as Simple GPIO.

### 7.3.1.7 $I^2C$

There are 2 $I^2C$ ports consisting of 2 pins each. Although no GPIO is available on these pins, they can be alternately programmed as CAN1 pins (on $I^2C1$) and/or as the ATA Chip Selects (on $I^2C2$). If the alternate function is specified, the associated $I^2C$ port is consumed and unavailable.

### 7.3.1.8 GPIO Timer Pins

The GPIO Timer port consists of 8 pins. Each pin is driven by a internal timer module, which can do either of the following:

- drive the pin in Output Compare mode and Pulse Width Modulation mode, or
- monitor the pin as input in Input Capture mode.

Additionally, the timer module can operate the pin as a Simple GPIO. This GPIO control is handled in the Timer Module register, see Section 7.4.4, “GPT Registers”. If the pin is controlled as a GPIO, then the Timer Module timer can be used as an internal CPU timer.

The Timer pins can be reconfigured for alternate functionality in the Port Configuration Register, as follows:

- Timer pins 0 and 1 can operate as CAN2 Tx/Rx or ATA Chip Selects.
- Timer pins 2–5 can operate as the SPI port.
- Timer pins 6 and 7 are dedicated as Timer GPIO and have no alternate function.

Although the Timer as GPIO only operates to the Simple GPIO level, Interrupt capability can be achieved by configuring the Timer for Input Capture mode.

#### 7.3.1.9 Dedicated GPIO Port

There is a dedicated GPIO port group that consists of 2 pins. Both pins operate at the WakeUp GPIO level. They are designated:

- GPIO_WKUP_6
- GPIO_WKUP_7

However, GPIO_WKUP_6 is not dedicated and can be programmed to operate as a second SDRAM memory chip select. As such, this pin is connected to the Memory Vdd supply. For Dual Data Rate memory, the GPIO_WKUP_6 pin is driven at the reduced 2.5V level.

If not used as a memory chip select, the GPIO_WKUP_6 pin serves as a memory voltage compatible GPIO.

### 7.3.2 GPIO Programmer's Model

The GPIO programmer's model contains 3 separate register sets (or modules), each at different offsets from MBAR. These register sets are:

1. GPIO Standard Registers. Output Only, Simple, and Interrupt GPIO are controlled by registers within this module. There are 3 register groupings for individual control of each of the named GPIO types.
2. WakeUp GPIO Registers. WakeUp GPIO are controlled by this register set
3. GPT Registers. Timer functions and Timer GPIO are controlled by this module.

All GPIO functionality is dependent on the Port Configuration Register (PCR) setting. The PCR is the first register in the GPIO Standard Module. This register controls the Pin MUX Logic. Therefore, the PCR also controls the physical routing of MPC5200B I/O pins to and from internal logic. The PCR is expected to be configured early in the boot process and set to a static value that supports the given peripheral set of a specific application.

**NOTE**

The PCR is **not** accessible during Deep Sleep mode.

#### 7.3.2.1 GPIO Standard Registers

The GPIO Standard Register set has separate registers for each GPIO type.

- Simple
- Output Only
- Interrupt

These registers are at an offset of MBAR + 0x0B00.

The GPIO Standard Register set uses 16 32-bit registers. These registers are located at an offset from MBAR of 0x0B00. Register addresses are relative to this offset. Therefore, the actual register address is: MBAR + 0x0B00 + register address.

Hyperlinks to the GPIO pin type registers are provided below:

- GPS Port Configuration Register (0x0B00)
- GPS Simple GPIO Enables Register (0x0B04)
- GPS Simple GPIO Open Drain Type Register (0x0B08)
- GPS Simple GPIO Data Direction Register (0x0B0C)
- GPS Simple GPIO Data Output Values Register (0x0B10)
- GPS Simple GPIO Data Input Values Register (0x0B14)
- GPS GPIO Output-Only Enables Register (0x0B18)
- GPS GPIO Output-Only Data Value Out Register (0x0B1C)
- GPS GPIO Simple Interrupt Enable Register (0x0B20)
- GPS GPIO Simple Interrupt Open-Drain Emulation Register (0x0B24)
- GPS GPIO Simple Interrupt Data Direction Register (0x0B28)
- GPS GPIO Simple Interrupt Data Value Out Register (0x0B2C)
- GPS GPIO Simple Interrupt Enable Register (0x0B30)
- GPS GPIO Simple Interrupt Types Register (0x0B34)
- GPS GPIO Simple Interrupt Master Enable Register (0x0B38)
- GPS GPIO Simple Interrupt Status Register (0x0B3C)

### 7.3.2.1.1 GPS Port Configuration Register

Address MBAR + 0x0B00

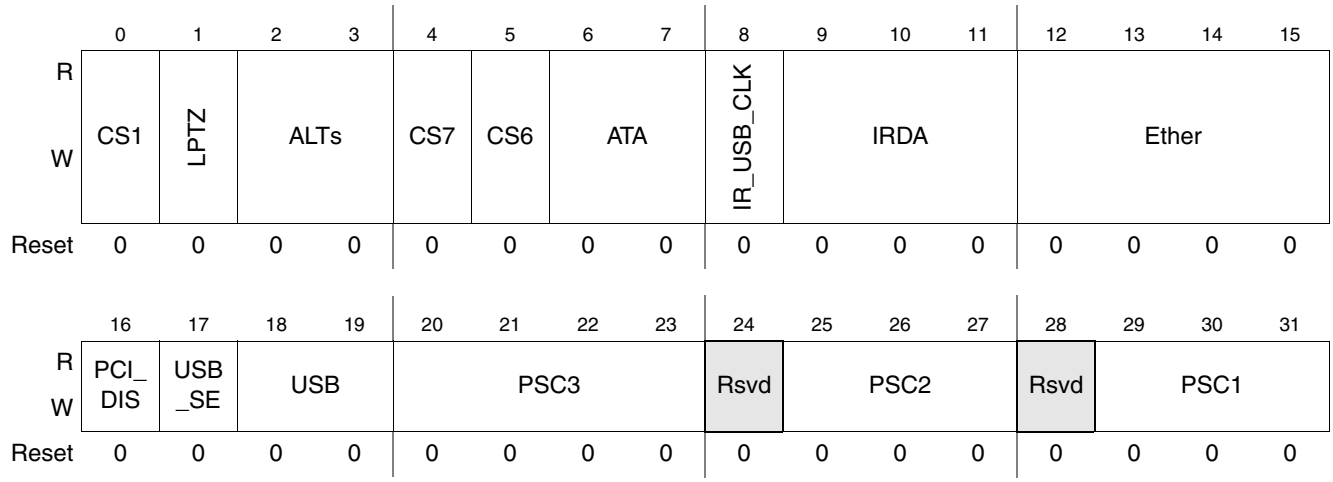



**Figure 7-20. GPS Port Configuration Register**

**Table 7-21. GPS Port Configuration Register Field Descriptions (Sheet 1 of 3)**

| Bit | Name | Description |
|---|---|---|
| 0 | CS1 | Memory Chip Select bit<br>0 gpio_wkup_6<br>1 mem_cs1 (second SDRAMC chip select) on gpio_wkup_6 pin |
| 1 | LPTZ | LocalPlus non-muxed TSIZ bit<br>0 gpio_wkup_7 and test_sel_1<br>1 TSIZ 1 on gpio_wkup_7 and TSIZ 2 on test_sel_1 |
| 2:3 | ALTs | Alternatives, see Note 2<br>00 No Alternatives: CAN1/2 on PSC2 according to PSC2 setting.<br>SPI on PSC3 according to PSC3 setting.<br>01 ALT CAN position: CAN1 on I2C1, CAN2 on Tmr0/1 pins, see Note 1<br>10 ALT SPI position: SPI on Tmr2/3/4/5 pins, see Note 2<br>11 Both on ALT |
| 4 | CS7 | 0 Interrupt GPIO on PSC3_5 (see note 6)<br>1 CS7 on PSC3_5 |
| 5 | CS6 | 0 Interrupt GPIO on PSC3_4 (see note 6)<br>1 CS6 on PSC3_4 |
| 6:7 | ATA | Advanced Technology Attachment<br>00 No ATA chip selects, csb_4/5 used as normal chip select<br>01 ATA cs0/1 on csb_4/5<br>10 ATA cs0/1 on i2c2 clk/io<br>11 ATA cs0/1 on Tmr0/1, see Note 1 |
| 8 | IR_USB_CLK | Infrared USB Clock<br>0 IrDA/USB 48MHz clock generated internally, pin is GPIO<br>1 IrDA/USB clock is sourced externally, input only |

**Table 7-21. GPS Port Configuration Register Field Descriptions (Sheet 2 of 3)**

| Bit | Name | Description |
|---|---|---|
| 9:11 | IRDA | Infrared Data Association<br>000 All IrDA pins are GPIOs<br>001 Reserved<br>010 Reserved<br>011 Reserved<br>100 Reserved<br>101 UART (without CD) / IrDA<br>110 Reserved<br>111 CODEC (without MCLK) / IrDA |
| 12: 15 | Ether | Ethernet<br>0000 All 18 Ethernet pins are GPIOs<br>0001 USB2 on Ethernet, see Note 3<br>0010 Ethernet 10Mbit (7-wire) mode<br>0011 Ethernet 7-wire and USB2, see Note 3<br>0100 Ethernet 100Mbit without MD<br>0101 Ethernet 100Mbit with MD<br>011X Reserved<br>1000 Ether 7-wire, UARTe, J1850<br>1001 Ether 7-wire, J1850<br>1010 Two UARTes, J1850<br>1011 One UARTe, J1850<br>1100 J1850<br>1101 Reserved<br>111X Reserved |
| 16 | PCI_DIS | 0 PCI controller enabled<br>1 PCI controller disabled.<br>When Large Flash or Most Graphics modes are enabled on the LocalPlus bus interface, the PCI interface can not be used (PCI control signals are used to support these modes).<br>When these modes are enabled (see LocalPlus control registers), the PCI controller must be disabled to prevent interference.<br>If these modes are enabled at boot, this bit will come out of reset set to 1.<br>If these modes are not enabled at boot, this bit will come out of reset set to 0. |
| 17 | USB_SE | USB Single Ended mode.<br>The USB interface is able to support both Differential and Single Ended modes. This bit allows the USB I/O interface to be programmed to Single Ended mode. Differential mode supplies TXP/TXN and RXP/TXN.<br>Single ended mode supplies TXP/TX_SE0 and RXP/RX_SE0.<br>This bit controls all USB ports (i.e. they are not individually programmable). Default is Differential mode.<br>0 Differential mode (Default after reset)<br>1 Single ended mode |
| 18:19 | USB | 00 4 GPIOs and 1 **Interrupt GPIO**<br>01 USB<br>10 Two UARTs<br>11 Reserved |

**Table 7-21. GPS Port Configuration Register Field Descriptions (Sheet 3 of 3)**

| Bit | Name | Description |
|---|---|---|
| 20:23 | PSC3 | Programmable Serial Controller 3<br>0000 All PSC3 pins are GPIOs<br>0001 USB2 on PSC3, no GPIOs available, see Note 3<br>001X Reserved<br>0100 UART functionality without CD<br>0101 UARTe functionality with CD<br>0110 CODEC3 functionality<br>0111 CODEC3 functionality (with MCLK)<br>100X SPI<br>101X Reserved<br>1100 SPI with UART3<br>1101 SPI with UART3e<br>111X SPI with CODEC3 |
| 24 | — | Reserved |
| 25:27 | PSC2 | Programmable Serial Controller 2<br>000 All PSC2 pins are GPIOs<br>001 CAN1&2 on PSC2 pins, see Note 1<br>01X AC97 functionality<br>100 UART functionality without CD<br>101 UARTe functionality with CD<br>110 CODEC2 functionality (without MCLK)<br>111 CODEC2 functionality (with MCLK) |
| 28 | — | Reserved |
| 29:31 | PSC1 | Programmable Serial Controller 1<br>00X All PSC1 pins are GPIOs<br>01X AC97 functionality<br>100 UART functionality without CD<br>101 UARTe functionality with CD<br>110 CODEC1 functionality (without MCLK)<br>111 CODEC1 functionality (with MCLK) |

**Note:**

1. ALT CAN cannot exist with ATA on Tmr0/1, not with CAN on PSC2.
2. ALT SPI cannot exist with any SPI on PCS3.
3. USB cannot exist on both Either and PSC3.
4. See Section 7.3.1, “GPIO Pin Multiplexing” or Table 2-1 or Table 2-2 to determine GPIO availability for the various PCR field settings.
5. If Large Flash or Most Graphics mode is enabled at boot, using a reset configuration bit, PCI disable will come out of reset set to 1. If these modes are not enabled at boot, this bit will come out of reset set to 0.
6. PSC3_4 and PSC3_5 default to zero (interrupt gpio) after reset. However, if the PSC3 is programmed to USB2 mode RXP and RXN will be on these pins. If PSC is programmed to UARTe mode, CD will be on the PSC3_4 pin.

### 7.3.2.1.2 GPS Simple GPIO Enables Register

Address MBAR + 0x0B04

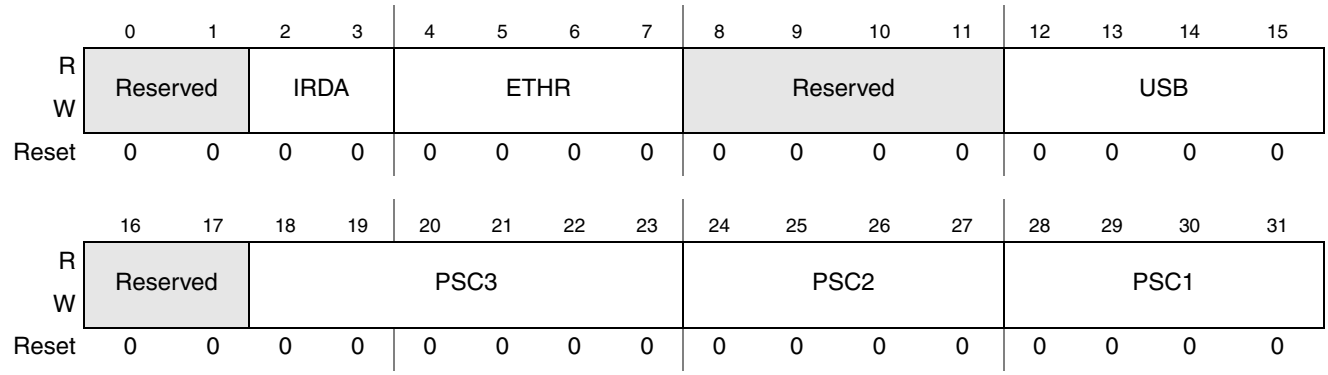



**Figure 7-21. GPS Simple GPIO Enables Register**

**Table 7-22. GPS Simple GPIO Enables Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2:3 | IRDA | Individual enable bits for the 2 Simple GPIO on IRDA port.<br>bit 2 controls IR_USB_CLK pin<br>bit 3 controls IRDA_TX pin<br>0 Disabled for GPIO (default)<br>1 Enabled for GPIO |
| 4:7 | ETHR | Individual enable bits for the 4 Simple GPIO on ETHR port.<br>bit 4 controls ETH_11 pin<br>bit 5 controls ETH_10 pin<br>bit 6 controls ETH_9 pin<br>bit 7 controls ETH_8 pin<br>0 Disabled for GPIO (default)<br>1 Enabled for GPIO |
| 8:11 | — | Reserved |
| 12:15 | USB | Individual enable bits for the 4 Simple GPIO on USB port.<br>bit 12 controls USB1_8 pin<br>bit 13 controls USB1_7 pin<br>bit 14 controls USB1_6 pin<br>bit 15 controls USB1_0 pin<br>0 Disabled for GPIO (default)<br>1 Enabled for GPIO |
| 16:17 | — | Reserved |
| 18:23 | PSC3 | Individual enable bits for the 6 Simple GPIO on PSC3 port.<br>bit 18 controls PSC3_7 pin<br>bit 19 controls PSC3_6 pin<br>bit 20 controls PSC3_3 pin<br>bit 21 controls PSC3_2 pin<br>bit 22 controls PSC3_1 pin<br>bit 23 controls PSC3_0 pin<br>0 Disabled for GPIO (default)<br>1 Enabled for GPIO |

**Table 7-22. GPS Simple GPIO Enables Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 24:27 | PSC2 | Individual enable bits for the 4 Simple GPIO on PSC2 port.<br>bit 24 controls GPIO_PSC2_3 (PSC2_3 pin)<br>bit 25 controls GPIO_PSC2_2 (PSC2_2 pin)<br>bit 26 controls GPIO_PSC2_1 (PSC2_1 pin)<br>bit 27 controls GPIO_PSC2_0 (PSC2_0 pin)<br>0 = Disabled for GPIO (default)<br>1 = Enabled for GPIO |
| 28:31 | PSC1 | Individual enable bits for the 4 Simple GPIO on PSC1 port.<br>bit 28 controls GPIO_PSC1_3 (PSC1_3 pin)<br>bit 29 controls GPIO_PSC1_2 (PSC1_2 pin)<br>bit 30 controls GPIO_PSC1_1 (PSC1_1 pin)<br>bit 31 controls GPIO_PSC1_0 (PSC1_0 pin)<br>0 = Disabled for GPIO (default)<br>1 = Enabled for GPIO |

### 7.3.2.1.3 GPS Simple GPIO Open Drain Type Register

Address MBAR + 0x0B08

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | IRDA | | ETHR | | | | Reserved | | | | USB | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | PSC3 | | | | | | PSC2 | | | | PSC1 | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-22. GPS Simple GPIO Open Drain Type Register**

**Table 7-23. GPS Simple GPIO Open Drain Type Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2:3 | IRDA | Individual bits to cause open drain emulation for pins configured as GPIO output.<br>bit 2 controls IR_USB_CLK pin<br>bit 3 controls IRDA_TX pin<br>0 Normal CMOS output (default)<br>1 Open Drain emulation (a drive to high creates Hi-Z) |
| 4:7 | ETHR | Individual bits to cause open drain emulation for pins configured as GPIO output.<br>bit 4 controls ETH_11 pin<br>bit 5 controls ETH_10 pin<br>bit 6 controls ETH_9 pin<br>bit 7 controls ETH_8 pin<br>0 Normal CMOS output (default)<br>1 Open Drain emulation (a drive to high creates Hi-Z) |

**Table 7-23. GPS Simple GPIO Open Drain Type Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 8:11 | — | Reserved |
| 12:15 | USB | Individual bits to cause open drain emulation for pins configured as GPIO output.<br>bit 12 controls USB1_8 pin<br>bit 13 controls GUSB1_7 pin<br>bit 14 controls USB1_6 pin<br>bit 15 controls USB1_0 pin<br>0 Normal CMOS output (default)<br>1 Open Drain emulation (a drive to high creates Hi-Z) |
| 16:17 | — | Reserved |
| 18:23 | PSC3 | Individual bits to cause open drain emulation for pins configured as GPIO output.<br>bit 18 controls PSC3_7 pin<br>bit 19 controls PSC3_6 pin<br>bit 20 controls PSC3_3 pin<br>bit 21 controls PSC3_2 pin<br>bit 22 controls PSC3_1 pin<br>bit 23 controls PSC3_0 pin<br>0 Normal CMOS output (default)<br>1 Open Drain emulation (a drive to high creates Hi-Z) |
| 24:27 | PSC2 | Individual bits to cause open drain emulation for pins configured as GPIO output.<br>bit 24 controls PSC2_3 pin<br>bit 25 controls PSC2_2 pin<br>bit 26 controls PSC2_1 pin<br>bit 27 controls PSC2_0 pin<br>0 Normal CMOS output (default)<br>1 Open Drain emulation (a drive to high creates Hi-Z) |
| 28:31 | PSC1 | Individual bits to cause open drain emulation for pins configured as GPIO output.<br>bit 28 controls PSC1_3 pin<br>bit 29 controls PSC1_2 pin<br>bit 30 controls PSC1_1 pin<br>bit 31 controls PSC1_0 pin<br>0 Normal CMOS output (default)<br>1 Open Drain emulation (a drive to high creates Hi-Z) |

### 7.3.2.1.4 GPS Simple GPIO Data Direction Register

Address MBAR + 0x0B0C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | IRDA | | ETHR | | | | Reserved | | | | USB | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | PSC3 | | | | | | PSC2 | | | | PSC1 | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-23. GPS Simple GPIO Data Direction Register**

**Table 7-24. GPS Simple GPIO Data Direction Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2:3 | IRDA | Individual bits to control directionality of the pin as GPIO.<br>bit 2 controls R_USB_CLK pin<br>bit 3 controls IRDA_TX pin<br>0 Pin is Input (default)<br>1 Pin is Output |
| 4:7 | ETHR | Individual bits to control directionality of the pin as GPIO.<br>bit 4 controls ETH_11 pin<br>bit 5 controls ETH_10 pin<br>bit 6 controls ETH_9 pin<br>bit 7 controls ETH_8 pin<br>0 Pin is Input (default)<br>1 Pin is Output |
| 8:11 | — | Reserved |
| 12:15 | USB | Individual bits to control directionality of the pin as GPIO.<br>bit 12 controls USB1_8 pin<br>bit 13 controls USB1_7 pin<br>bit 14 controls USB1_6 pin<br>bit 15 controls USB1_0 pin<br>0 Pin is Input (default)<br>1 Pin is Output |
| 16:17 | — | Reserved |
| 18:23 | PSC3 | Individual bits to control directionality of the pin as GPIO.<br>bit 18 controls PSC3_7 pin<br>bit 19 controls PSC3_6 pin<br>bit 20 controls PSC3_3 pin<br>bit 21 controls PSC3_2 pin<br>bit 22 controls PSC3_1 pin<br>bit 23 controls PSC3_0 pin<br>0 Pin is Input (default)<br>1 Pin is Output |

**Table 7-24. GPS Simple GPIO Data Direction Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 24:27 | PSC2 | Individual bits to control directionality of the pin as GPIO.<br>bit 24 controls PSC2_3 pin<br>bit 25 controls PSC2_2 pin<br>bit 26 controls PSC2_1 pin<br>bit 27 controls PSC2_0 pin<br>0 = Pin is Input (default)<br>1 = Pin is Output |
| 28:31 | PSC1 | Individual bits to control directionality of the pin as GPIO.<br>bit 28 controls PSC1_3 pin<br>bit 29 controls PSC1_2 pin<br>bit 30 controls PSC1_1 pin<br>bit 31 controls PSC1_0 pin<br>0 = Pin is Input (default)<br>1 = Pin is Output |

### 7.3.2.1.5 GPS Simple GPIO Data Output Values Register

Address MBAR + 0x0B10

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | IRDA | | ETHR | | | | Reserved | | | | USB | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | PSC3 | | | | | | PSC2 | | | | PSC1 | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-24. GPS Simple GPIO Data Output Values Register**

**Table 7-25. GPS Simple GPIO Data Output Values Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2:3 | IRDA | Individual bits to control the state of pins configured as GPIO output.<br>bit 2 controls IR_USB_CLK pin<br>bit 3 controls GPIO_IRDA_0 (IRDA_TX pin<br>0 Drive 0 on the pin (default)<br>1 Drive 1 on the pin |
| 4:7 | ETHR | Individual bits to control the state of pins configured as GPIO output.<br>bit 4 controls ETH_11 pin<br>bit 5 controls ETH_10 pin<br>bit 6 controls ETH_9 pin<br>bit 7 controls ETH_8 pin<br>0 Drive 0 on the pin (default)<br>1 Drive 1 on the pin |

**Table 7-25. GPS Simple GPIO Data Output Values Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 8:11 | — | Reserved |
| 12:15 | USB | Individual bits to control the state of pins configured as GPIO output.<br>bit 12 controls USB1_8 pin<br>bit 13 controls USB1_7 pin<br>bit 14 controls USB1_6 pin<br>bit 15 controls USB1_0 pin<br>0 Drive 0 on the pin (default)<br>1 Drive 1 on the pin |
| 16:17 | — | Reserved |
| 18:23 | PSC3 | Individual bits to control the state of pins configured as GPIO output.<br>bit 18 controls PSC3_7 pin<br>bit 19 controls PSC3_6 pin<br>bit 20 controls PSC3_3 pin<br>bit 21 controls PSC3_2 pin<br>bit 22 controls PSC3_1 pin<br>bit 23 controls PSC3_0 pin<br>0 Drive 0 on the pin (default)<br>1 Drive 1 on the pin |
| 24:27 | PSC2 | Individual bits to control the state of pins configured as GPIO output.<br>bit 24 controls PSC2_3 pin<br>bit 25 controls PSC2_2 pin<br>bit 26 controls PSC2_1 pin<br>bit 27 controls PSC2_0 pin<br>0 Drive 0 on the pin (default)<br>1 Drive 1 on the pin |
| 28:31 | PSC1 | Individual bits to control the state of pins configured as GPIO output.<br>bit 28 controls PSC1_3 pin<br>bit 29 controls PSC1_2 pin<br>bit 30 controls PSC1_1 pin<br>bit 31 controls PSC1_0 pin<br>0 Drive 0 on the pin (default)<br>1 Drive 1 on the pin |

### 7.3.2.1.6 GPS Simple GPIO Data Input Values Register

Address MBAR + 0x0B14

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | IRDA | | ETHR | | | | Reserved | | | | USB | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | PSC3 | | | | | | PSC2 | | | | PSC1 | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-25. GPS Simple GPIO Data Input Values Register**

**Table 7-26. GPS Simple GPIO Data Input Values Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2:3 | IRDA | Individual status bits reflecting the state of corresponding GPIO pins.<br>bit 2 reflects IR_USB_CLK pin<br>bit 3 reflects RDA_TX pin |
| 4:7 | ETHR | Individual status bits reflecting the state of corresponding GPIO pins.<br>bit 4 reflects ETH_11 pin<br>bit 5 reflects ETH_10 pin<br>bit 6 reflects ETH_9 pin<br>bit 7 reflects ETH_8 pin |
| 8:11 | — | Reserved |
| 12:15 | USB | Individual status bits reflecting the state of corresponding GPIO pins.<br>bit 12 reflects USB1_8 pin<br>bit 13 reflects USB1_7 pin<br>bit 14 reflects USB1_6 pin<br>bit 15 reflects USB1_0 pin |
| 16:17 | — | Reserved |
| 18:23 | PSC3 | Individual status bits reflecting the state of corresponding GPIO pins.<br>bit 18 reflects PSC3_7 pin<br>bit 19 reflects PSC3_6 pin<br>bit 20 reflects PSC3_3 pin<br>bit 21 reflects PSC3_2 pin<br>bit 22 reflects PSC3_1 pin<br>bit 23 reflects PSC3_0 pin |
| 24:27 | PSC2 | Individual status bits reflecting the state of corresponding GPIO pins.<br>bit 24 reflects PSC2_3 pin<br>bit 25 reflects PSC2_2 pin<br>bit 26 reflects PSC2_1 pin<br>bit 27 reflects PSC2_0 pin |
| 28:31 | PSC1 | Individual status bits reflecting the state of corresponding GPIO pins.<br>bit 28 reflects PSC1_3 pin<br>bit 29 reflects PSC1_2 pin<br>bit 30 reflects PSC1_1 pin<br>bit 31 reflects PSC1_0 pin |

**Note:** These status bits operate regardless of the function on the pin.

### 7.3.2.1.7 GPS GPIO Output-Only Enables Register

Address MBAR + 0x0B18

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | ETHR | | | | | | | | Reserved | | | | I2C | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-26. GPS GPIO Output-Only Enables Register**

**Table 7-27. GPS GPIO Output-Only Enables Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | ETHR | Individual bits to enable each Output Only GPIO pin—all reside on the Ethernet port.<br>bit 0 controls ETH_7 pin<br>bit 1 controls ETH_6 pin<br>bit 2 controls ETH_5 pin<br>bit 3 controls ETH_4 pin<br>bit 4 controls ETH_3 pin<br>bit 5 controls ETH_2 pin<br>bit 6 controls ETH_1 pin<br>bit 7 controls ETH_0 pin<br>0 Disabled for GPIO use (default)<br>1 Enabled for GPIO use |
| 8 :11 | — | Reserved |
| 12:15 | I2C | Individual bits to enable each Output Only GPIO pin—all reside on the I2C ports.<br>bit 12 controls I2C_2 pin<br>bit 13 controls I2C_3 pin<br>bit 14 controls I2C_0 pin<br>bit 15 controls I2C_1 pin<br>0 Disabled for GPIO use (default)<br>1 Enabled for GPIO use<br>This bits can be used to toggle the clock (SCL) and data (SDA) lines of the I2C interface. |
| 16:31 | — | Reserved |

### 7.3.2.1.8 GPS GPIO Output-Only Data Value Out Register

Address MBAR + 0x0B1C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | ETHR | | | | | | | | Reserved | | | | I2C | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-27. GPS GPIO Output-Only Data Value Out Register**

**Table 7-28. GPS GPIO Output-Only Data Value Out Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | ETHR | Individual bits to control the state of enabled Output Only GPIO pins.<br>bit 0 controls ETH_7 pin<br>bit 1 controls ETH_6 pin<br>bit 2 controls ETH_5 pin<br>bit 3 controls ETH_4 pin<br>bit 4 controls ETH_3 pin<br>bit 5 controls ETH_2 pin<br>bit 6 controls ETH_1 pin<br>bit 7 controls ETH_0 pin<br>0 Drive 0 on the pin (default)<br>1 Drive 1 on the pin |
| 8 :11 | — | Reserved |
| 12:15 | I2C | Individual bits to control the state of enabled Output Only GPIO pins — all reside on the I2C ports.<br>bit 12 controls I2C_2 pin<br>bit 13 controls I2C_3 pin<br>bit 14 controls I2C_0 pin<br>bit 15 controls I2C_1 pin<br>0 Drive 0 on the pin (default)<br>1 Drive 1 on the pin<br>This bits can be used to toggle the clock (SCL) and data (SDA) lines of the I2C interface. |
| 16:31 | — | Reserved |

### 7.3.2.1.9 GPS GPIO Simple Interrupt Pin Enable Register

Address MBAR + 0x0B20

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | SIGPIOe | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 7-29. GPS GPIO Simple Interrupt Pin Enable Register**

**Table 7-30. GPS GPIO Simple Interrupt Pin Enable Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | SIGPIOE | Individual bits to enable each Interrupt GPIO pin (pins are scattered).<br>bit 0 controls ETH_16 pin<br>bit 1 controls ETH_15 pin<br>bit 2 controls ETH_14 pin<br>bit 3 controls ETH_13 pin<br>bit 4 controls USB1_9 pin<br>bit 5 controls PSC3_8 pin<br>bit 6 controls PSC3_5 pin<br>bit 7 controls PSC3_4 pin<br>0 disabled for GPIO use (default)<br>1 enabled for GPIO use |
| 8:31 | — | Reserved |

### 7.3.2.1.10 GPS GPIO Simple Interrupt Open-Drain Emulation Register

Address MBAR + 0x0B24

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | SIODe | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-28. GPS GPIO Simple Interrupt Open-Drain Emulation Register**

**Table 7-31. GPS GPIO Simple Interrupt Open-Drain Emulation Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | SIODe | Individual bits to cause open drain emulation for pins configured as GPIO output.<br>bit 0 controls ETH_16 pin<br>bit 1 controls ETH_15 pin<br>bit 2 controls ETH_14 pin<br>bit 3 controls ETH_13 pin<br>bit 4 controls USB1_9 pin<br>bit 5 controls PSC3_8 pin<br>bit 6 controls PSC3_5 pin<br>bit 7 controls PSC3_4 pin<br>0 Normal CMOS output (default)<br>1 Open Drain emulation (a drive to high creates Hi-Z) |
| 8:31 | — | Reserved |

### 7.3.2.1.11 GPS GPIO Simple Interrupt Data Direction Register

Address MBAR + 0x0B28

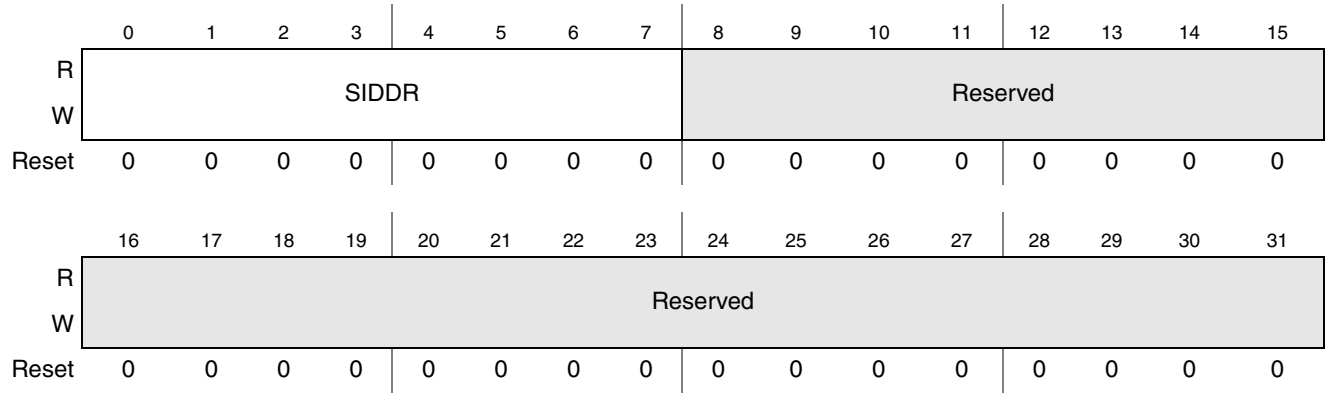



**Figure 7-29. GPS GPIO Simple Interrupt Data Direction Register**

**Table 7-32. GPS GPIO Simple Interrupt Data Direction Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | SIDDR | Individual bits to control direction of the pin as GPIO.<br>bit 0 controls ETH_16 pin<br>bit 1 controls ETH_15 pin<br>bit 2 controls ETH_14 pin<br>bit 3 controls ETH_13 pin<br>bit 4 controls USB1_9 pin<br>bit 5 controls PSC3_8 pin<br>bit 6 controls PSC3_5 pin<br>bit 7 controls PSC3_4 pin<br>0 Pin is Input (default)<br>1 Pin is Output |
| 8:31 | — | Reserved |

### 7.3.2.1.12 GPS GPIO Simple Interrupt Data Value Out Register

Address MBAR + 0x0B2C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | SIDVO | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-30. GPS GPIO Simple Interrupt Data Value Out Register**

**Table 7-33. GPS GPIO Simple Interrupt Data Value Out Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | SIDVO | Individual bits to control the state of pins configured as GPIO output.<br>bit 0 controls ETH_16 pin<br>bit 1 controls ETH_15 pin<br>bit 2 controls ETH_14 pin<br>bit 3 controls ETH_13 pin<br>bit 4 controls USB1_9 pin<br>bit 5 controls PSC3_8 pin<br>bit 6 controls PSC3_5 pin<br>bit 7 controls PSC3_4 pin<br>0 Drive 0 on the pin (default)<br>1 Drive 1 on the pin |
| 8:31 | — | Reserved |

### 7.3.2.1.13 GPS GPIO Simple Interrupt Enable Register

Address MBAR + 0x0B30

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | SIINTEN | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-31. GPS GPIO Simple Interrupt Enable Register**

**Table 7-34. GPS GPIO Simple Interrupt Enable Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | SIINTEN | Individual bits to enable Interrupt generation for each GPIO pin configured as an Input.<br>bit 0 controls ETH_16 pin<br>bit 1 controls ETH_15 pin<br>bit 2 controls ETH_14 pin<br>bit 3 controls ETH_13 pin<br>bit 4 controls USB1_9 pin<br>bit 5 controls PSC3_8 pin<br>bit 6 controls PSC3_5 pin<br>bit 7 controls PSC3_4 pin<br>0 Pin cannot generate an Interrupt (default)<br>1 Pin can generate an Interrupt if configured as an Input GPIO |
| 8:31 | — | Reserved |

**Note:** See Interrupt Type data in GPS GPIO Simple Interrupt Types Register Register. Also, the Master Interrupt Enable bit must be set in the GPS GPIO Simple Interrupt Master Enable Register Register, before any Simple Interrupt pin can generate an Interrupt.

### 7.3.2.1.14 GPS GPIO Simple Interrupt Types Register

Address MBAR + 0x0B34

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | ITYP7 | | ITYP6 | | ITYP5 | | ITYP4 | | ITYP3 | | ITYP2 | | ITYP1 | | ITYP0 | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-32. GPS GPIO Simple Interrupt Types Register**

**Table 7-35. GPS GPIO Simple Interrupt Types Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:15 | ITYP[0:7] | GPIO Interrupt Type bits for Simple-Interrupt GPIO pin 7.<br>ITYP7—bits 0:1 controls ETH_16 pin<br>ITYP6—bits 2:3 controls ETH_15 pin<br>ITYP5—bits 4:5 controls ETH_14 pin<br>ITYP4—bits 6:7 controls ETH_13 pin<br>ITYP3—bits 8:9 controls USB1_9 pin<br>ITYP2—bits 10:11 controls PSC3_8 pin<br>ITYP1—bits 12:13 controls PSC3_5 pin<br>ITYP0—bits 14:15 controls PSC3_4 pin<br>00 Interrupt on any transition<br>01 Interrupt on rising edge<br>10 Interrupt on falling edge<br>11 Interrupt on pulse (any two transitions) |
| 16:31 | — | Reserved |

### 7.3.2.1.15 GPS GPIO Simple Interrupt Master Enable Register

Address MBAR + 0x0B38

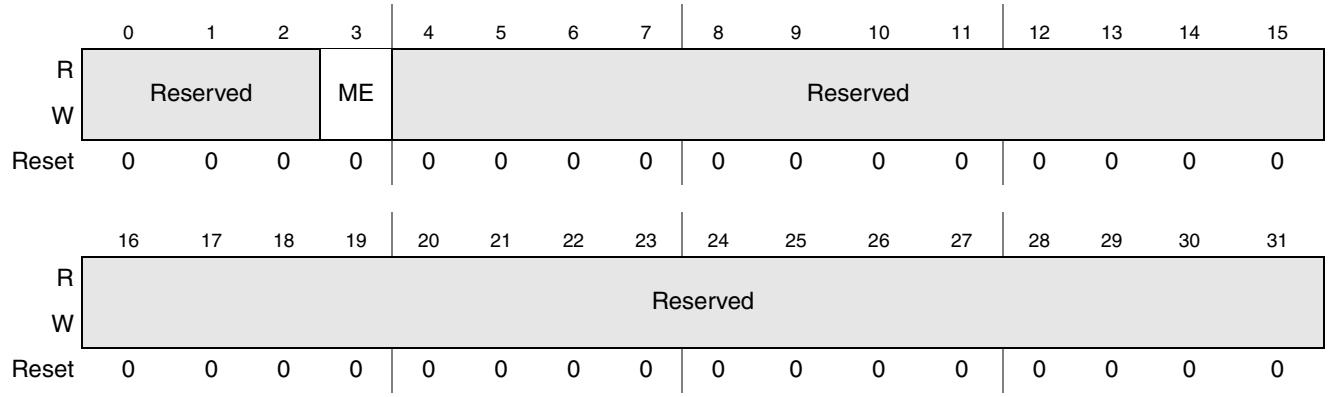



**Figure 7-33. GPS GPIO Simple Interrupt Master Enable Register**

**Table 7-36. GPS GPIO Simple Interrupt Master Enable Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:2 | — | Reserved |
| 3 | ME | GPIO Simple Interrupt Master Enable pin—This pin must be high before any Simple Interrupt pin can generate an interrupt. This bit should remain clear while programming individual interrupts, then set high as a final step. This prevents any spurious interrupt occurring during programming. |
| 4:31 | — | Reserved |

### 7.3.2.1.16 GPS GPIO Simple Interrupt Status Register

Address MBAR + 0x0B3C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | ISTAT | | | | | | | | IVAL | | | | | | | |
| W | rwc | rwc | rwc | rwc | rwc | rwc | rwc | rwc | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-34. GPS GPIO Simple Interrupt Status Register**

**Table 7-37. GPS GPIO Simple Interrupt Status Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | ISTAT | Interrupt Status—status bit for GPIO Simple interrupt pins 7 to 0, where 1 indicates an interrupt has occurred. Clear bit with a Sticky bit write to 1.<br>Bit 0 reflects ETH_16 pin<br>Bit 1 reflects ETH_15 pin<br>Bit 2 reflects ETH_14 pin<br>Bit 3 reflects ETH_13 pin<br>Bit 4 reflects USB1_9 pin<br>Bit 5 reflects PSC3_8 pin<br>Bit 6 reflects PSC3_5 pin<br>Bit 7 reflects PSC3_4 pin |
| 8:15 | IVAL | Input Value—status bit for GPIO Simple Interrupt pins 7 to 0. This is the raw state of the input pin at the time this register is read. It is not latched to the state that caused the Interrupt (if any).<br>Bit 8 reflects ETH_16 pin<br>Bit 9 reflects ETH_15 pin<br>Bit 10 reflects ETH_14 pin<br>Bit 11 reflects ETH_13 pin<br>Bit 12 reflects USB1_9 pin<br>Bit 13 reflects PSC3_8 pin<br>Bit 14 reflects PSC3_5 pin<br>Bit 15 reflects PSC3_4 pin<br>IVAL is always available regardless of enable or setting, even if not used as GPIO.<br>Writing to this byte has no effect. |
| 16:31 | — | Reserved |

### 7.3.2.2 WakeUp GPIO Registers

The WakeUp GPIO Register Set provides GPIO control for the 8 WakeUp GPIO pins. These pins are scattered throughout the pin groups, but are all controlled in this module. It should be noted that WakeUp GPIO can operate as Simple Interrupt GPIO. Because of this, there are separate registers to enable these pins as Wakeup interrupts and/or Simple Interrupts. The distinction between these two types of interrupts is made according to the powered state of MPC5200B.

- In Deep Sleep mode, the WakeUp Interrupt enables are used.
- In all other modes, the Simple Interrupt enables are used.

In either of the above types of interrupts, we are referring to the WakeUp GPIO and the registers in this module. These are not to be confused with the Simple Interrupt GPIO pins, which are controlled in the previous module, GPIO Standard.

This WakeUp GPIO register set uses 10 32-bit registers. These registers are located at an offset from MBAR of 0x0C00. Register addresses are relative to this offset. Therefore, the actual register address is:
**MBAR + 0x0C00 + register address**

Hyperlinks to the WakeUp GPIO registers are provided below:

- GPW WakeUp GPIO Enables Register (0x0C00)
- GPW WakeUp GPIO Open Drain Emulation Register (0x0C04)
- GPW WakeUp GPIO Data Direction Register (0x0C08)
- GPW WakeUp GPIO Data Value Out Register (0x0C0C)
- GPW WakeUp GPIO Interrupt Enable Register (0x0C10)
- GPW WakeUp GPIO Individual Interrupt Enable Register (0x0C14)
- GPW WakeUp GPIO Interrupt Types Register (0x0C18)
- GPW WakeUp GPIO Master Enables Register (0x0C1C)
- GPW WakeUp GPIO Data Input Values Register (0x0C20)
- GPW WakeUp GPIO Status Register (0x0C24)

### 7.3.2.2.1 GPW WakeUp GPIO Enables Register

Address MBAR + 0x0C00

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | WGPIOe | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-35. GPW WakeUp GPIO Enables Register**

**Table 7-38. GPW WakeUp GPIO Enables Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | WGPIOe | Bits to enable the operation of individual wakeup GPIO pins.<br>Bit 0 controls GPIO_WKUP_7 pin<br>Bit 1 controls GPIO_WKUP_6 pin<br>Bit 2 controls PSC6_1 pin<br>Bit 3 controls PSC6_0 pin<br>Bit 4 controls ETH_17 pin<br>Bit 5 controls PSC3_9 pin<br>Bit 6 controls PSC2_4 pin<br>Bit 7 controls PSC1_4 pin<br>0 Pin not enabled for any GPIO use (default).<br>1 Pin enabled for use as GPIO. |
| 8:31 | — | Reserved |

### 7.3.2.2.2 GPW WakeUp GPIO Open Drain Emulation Register

Address MBAR + 0x0C04

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | WODe | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-36. GPW WakeUp GPIO Open Drain Emulation Register**

**Table 7-39. GPW WakeUp GPIO Open Drain Emulation Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | WODe | Bits to control open drain emulation for individual WakeUp GPIO configured as outputs.<br>Bit 0 controls GPIO_WKUP_7 pin<br>Bit 1 controls GPIO_WKUP_6 pin<br>Bit 2 controls PSC6_1 pin<br>Bit 3 controls PSC6_0 pin<br>Bit 4 controls ETH_17 pin<br>Bit 5 controls PSC3_9 pin<br>Bit 6 controls PSC2_4 pin<br>Bit 7 controls PSC1_4 pin<br>0 Normal CMOS output (default).<br>1 Open Drain emulation (a drive to high creates Hi-Z). |
| 8:31 | — | Reserved |

### 7.3.2.2.3 GPW WakeUp GPIO Data Direction Register

Address MBAR + 0x0C08

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | WDDR[7:0] | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-37. GPW WakeUp GPIO Data Direction Register**

**Table 7-40. GPW WakeUp GPIO Data Direction Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | WDDR[7:0] | Individual bits to control directionality of the pin as GPIO.<br>Bit 0 controls GPIO_WKUP_7 pin<br>Bit 1 controls GPIO_WKUP_6 pin<br>Bit 2 controls PSC6_1 pin<br>Bit 3 controls PSC6_0 pin<br>Bit 4 controls ETH_17 pin<br>Bit 5 controls PSC3_9 pin<br>Bit 6 controls PSC2_4 pin<br>Bit 7 controls PSC1_4 pin<br>0 Pin is Input (default).<br>1 Pin is Output. |
| 8:31 | — | Reserved |

### 7.3.2.2.4 GPW WakeUp GPIO Data Value Out Register

Address MBAR + 0x0C0C

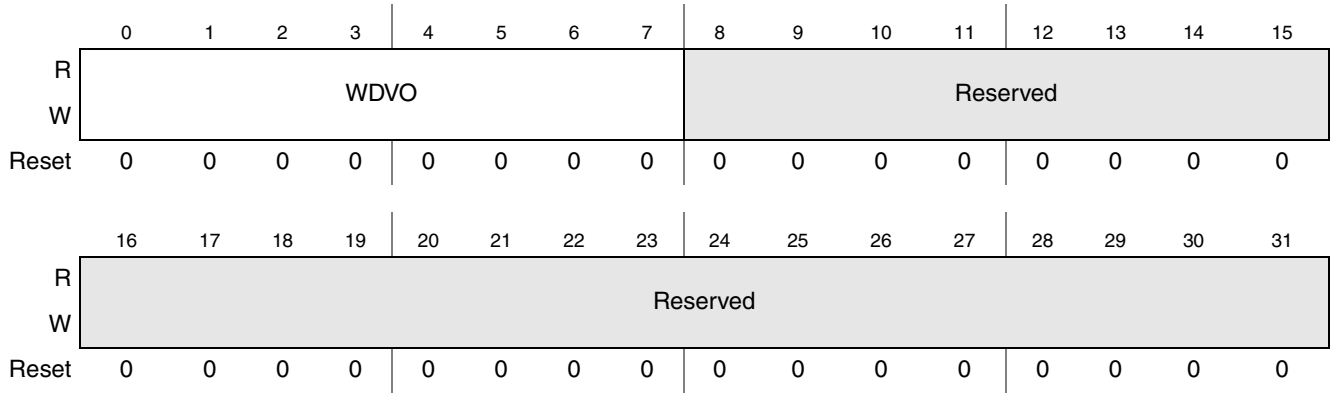



**Figure 7-38. GPW WakeUp GPIO Data Value Out Register**

**Table 7-41. GPW WakeUp GPIO Data Value Out Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | WDVO | Individual bits to control the state of pins configured as GPIO output.<br>Bit 0 controls GPIO_WKUP_7 pin<br>Bit 1 controls GPIO_WKUP_6 pin<br>Bit 2 controls PSC6_1 pin<br>Bit 3 controls PSC6_0 pin<br>Bit 4 controls ETH_17 pin<br>Bit 5 controls PSC3_9 pin<br>Bit 6 controls PSC2_4 pin<br>Bit 7 controls PSC1_4 pin<br>0 Drive 0 on the pin (default).<br>1 Drive 1 on the pin.<br>**Note:** If pin is emulating open drain, this setting results in Hi-Z |
| 8:31 | — | Reserved |

### 7.3.2.2.5 GPW WakeUp GPIO Interrupt Enable Register

Address MBAR + 0x0C10

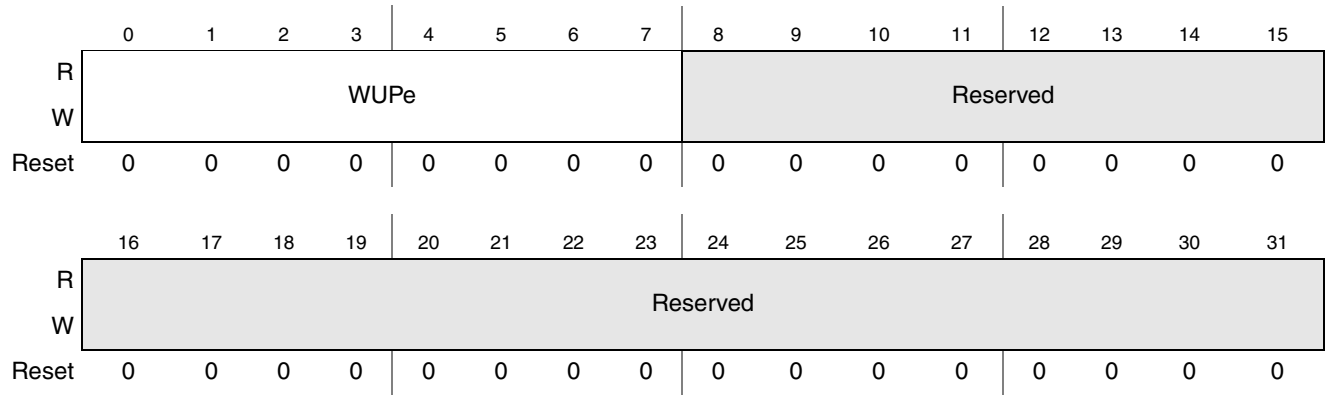



**Figure 7-39. GPW WakeUp GPIO Interrupt Enable Register**

**Table 7-42. GPW WakeUp GPIO Interrupt Enable Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | WUPe | Individual bits to enable generation of WakeUp interrupt for WakeUp GPIO configured as input.<br>Bit 0 controls GPIO_WKUP_7 pin<br>Bit 1 controls GPIO_WKUP_6 pin<br>Bit 2 controls PSC6_1 pin<br>Bit 3 controls PSC6_0 pin<br>Bit 4 controls ETH_17 pin<br>Bit 5 controls PSC3_9 pin<br>Bit 6 controls PSC2_4 pin<br>Bit 7 controls PSC1_4 pin<br>0 Pin cannot generate WakeUp Interrupt (default).<br>1 Pin can generate WakeUp Interrupt while MPC5200B is in Deep Sleep mode.<br>**Note:** These enable bits apply ONLY when MPC5200B is in Deep Sleep mode. |
| 8:31 | — | Reserved |

**Note:** Only valid when Port Configuration indicates GPIO usage and pin is configured as input in the associated DDR bit in GPIOWDO. Also, Master Interrupt Enable bit in GPIOWME must be set.

### 7.3.2.2.6 GPW WakeUp GPIO Individual Interrupt Enable Register

Address MBAR + 0x0C14

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | WINe | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-40. GPW WakeUp GPIO Individual Interrupt Enable Register**

**Table 7-43. GPW WakeUp GPIO Individual Interrupt Enable Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | WINe | Individual bits to enable generation of Simple interrupt for WakeUp GPIO configured as input.<br>Bit 0 controls GPIO_WKUP_7 pin<br>Bit 1 controls GPIO_WKUP_6 pin<br>Bit 2 controls PSC6_1 pin<br>Bit 3 controls PSC6_0 pin<br>Bit 4 controls ETH_17 pin<br>Bit 5 controls PSC3_9 pin<br>Bit 6 controls PSC2_4 pin<br>Bit 7 controls PSC1_4 pin<br>0 Pin cannot generate Simple Interrupt (default).<br>1 Pin can generate Simple Interrupt while MPC5200B is **not** in Deep Sleep mode.<br>**Note:** These enable bits apply **only** when MPC5200B is **not** in Deep Sleep mode. |
| 8:31 | — | Reserved |

**Note:** Only valid when Port Configuration indicates GPIO usage and pin is configured as input in the associated DDR bit in GPIOWDO. Also, Master Interrupt Enable bit in GPIOWME must be set.

### 7.3.2.2.7 GPW WakeUp GPIO Interrupt Types Register

Address MBAR + 0x0C18

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Ityp7 | | Ityp6 | | Ityp5 | | Ityp4 | | Ityp3 | | Ityp2 | | Ityp7 | | Ityp0 | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-41. GPW WakeUp GPIO Interrupt Types Register**

**Table 7-44. GPW WakeUp GPIO Interrupt Types Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | Ityp7 | GPIO Interrupt Type bits for WakeUp GPIO pins 7–0<br>00 Interrupt at any transition<br>01 Interrupt on rising edge<br>10 Interrupt on falling edge<br>11 Interrupt on pulse (any 2 transitions)<br>The above interrupt types describe operation for interrupts occurring while MPC5200B is **not** in Deep Sleep mode (i.e., Simple Interrupt types). For operation while in Deep Sleep mode the interpretation of these bits is slightly different, because no clocking is present in this mode and it is therefore impossible to detect an edge on the input. For Deep Sleep mode the bits are interpreted as follows:<br>00 Not Valid, no interrupt can be detected<br>01 Level High, any high creates WakeUp from Deep Sleep<br>10 Level Low, any low creates WakeUp from Deep Sleep<br>11 Not Valid, no interrupt can be detected.<br>ITYP7 controls GPIO_WKUP_7 pin<br>ITYP6 controls GPIO_WKUP_6 pin<br>ITYP5 controls PSC6_1 pin<br>ITYP4 controls PSC6_0 pin<br>ITYP3 controls ETH_17 pin<br>ITYP2 controls PSC3_9 pin<br>ITYP1 controls PSC2_4 pin<br>ITYP0 controls PSC1_4 pin<br>**Note:** Any GPIO WakeUp interrupt creates a Main Level 2 interrupt in the Interrupt Controller. |
| 2:3 | Ityp6 | |
| 4:5 | Ityp5 | |
| 6:7 | Ityp4 | |
| 8:9 | Ityp3 | |
| 10:11 | Ityp2 | |
| 12:13 | Ityp1 | |
| 14:15 | Ityp0 | |
| 16:31 | — | Reserved |

### 7.3.2.2.8 GPW WakeUp GPIO Master Enables Register

Address MBAR + 0x0C1C

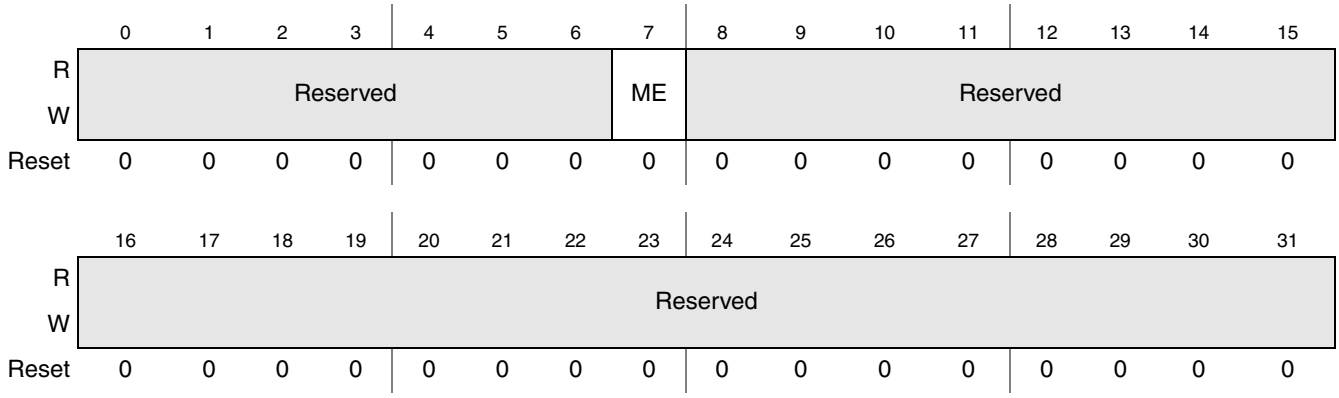



**Figure 7-42. GPW WakeUp GPIO Master Enables Register**

**Table 7-45. GPW WakeUp GPIO Master Enables Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7 | ME | WakeUp GPIO Master Enable pin. This pin must be high before **any** WakeUp GPIO pin can generate an interrupt. This bit should remain clear while programming individual interrupts and then set high as a final step. This prevents any spurious interrupt occurring during programming. |
| 8:31 | — | Reserved |

### 7.3.2.2.9 GPW WakeUp GPIO Data Input Values Register

Address MBAR + 0x0C20

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | WIVAL | | | | | | | | Reserved | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-43. GPW WakeUp GPIO Data Input Values Register**

**Table 7-46. GPW WakeUp GPIO Data Input Values Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | WIVAL | Input Value bits for GPIO WakeUp pins 7–0. This is the raw state of the input pin at the time this register is read. It is not latched to the state that caused the interrupt (if any).<br>This status bit is always available, regardless of any enable or setting. For example, even if the pin is not used as GPIO.<br>Writing to this byte has no effect.<br>Bit 0 reflects GPIO_WKUP_7 pin<br>Bit 1 reflects GPIO_WKUP_6 pin<br>Bit 2 reflects PSC6_1 pin<br>Bit 3 reflects PSC6_0 pin<br>Bit 4 reflects ETH_17 pin<br>Bit 5 reflects PSC3_9 pin<br>Bit 6 reflects PSC2_4 pin<br>Bit 7 reflects PSC1_4 pin |
| 8:31 | — | Reserved |

### 7.3.2.2.10 GPW WakeUp GPIO Status Register

Address MBAR + 0x0C24

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Istat | | | | | | | | Reserved | | | | | | | |
| W | rwc | rwc | rwc | rwc | rwc | rwc | rwc | rwc | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-44. GPW WakeUp GPIO Status Register**

**Table 7-47. GPW WakeUp GPIO Status Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | Istat | Interrupt status bits for GPIO WakeUp pins 7–0.<br>1 indicates an interrupt occurred. Cleared with a sticky-bit write to a 1 to clear the interrupt condition.<br>Bit 0 reflects interrupt on GPIO_WKUP_7 pin<br>Bit 1 reflects interrupt on GPIO_WKUP_6 pin<br>Bit 2 reflects interrupt on PSC6_1 pin<br>Bit 3 reflects interrupt on PSC6_0 pin<br>Bit 4 reflects interrupt on ETH_17 pin<br>Bit 5 reflects interrupt on PSC3_9 pin<br>Bit 6 reflects interrupt on PSC2_4 pin<br>Bit 7 reflects interrupt on PSC1_4 pin |
| 8:31 | — | Reserved |

## 7.4 General Purpose Timers (GPT)

Eight (8) General-Purpose Timer (GPT) pins are configurable for:

- Input Capture
- Output Compare
- Pulse Width Modulation (PWM) Output
- Simple GPIO
- Internal CPU timer
- Watchdog Timer (on GPT0 only)

Timer modules run off the internal IP bus clock. Each Timer is associated to a single I/O pin. Each Timer has a 16-bit prescaler and 16-bit counter, thus achieving a 32-bit range (but only 16-bit resolution).

### 7.4.1 Timer Configuration Method

Use the following method to configure each timer:

1. Determine the Mode Select field (Timer_MS) value for the desired operation.
2. Program any other registers associated with this mode.
3. Program Interrupt enable as desired.
4. Enable the Timer by writing the Mode Select value into the Timer_MS field.

### 7.4.2 Mode Overview

The following gives a brief description of the available modes:

1. **Input Capture**—In this mode the I/O pin is an Input. Once enabled, the counters run until the specified “Capture Event” occurs (rise, fall, either, or pulse). At the Capture Event, the counter value is latched in the status register. If enabled, a CPU interrupt is generated. The GP Timers 6 & 7 are active during low power modes (except for deep sleep), and therefore have the ability to initiate a wake up the device from a low-power mode.
2. **Output Compare**—In this mode the I/O pin is an Output. When enabled the counters run until they reach the programmed Terminal Count value. At this point, the specified “Output Event” is generated (toggle, pulse hi, or pulse low). If enabled, a CPU interrupt is generated.
3. **PWM**—In this mode the I/O pin is an Output. The user can program “Period” and “Width” values to create an adjustable, repeating output waveform on the I/O pin. A CPU interrupt can be generated at the beginning of each PWM Period, at which time a new Width value can be loaded. The new Width value, which represents “ON time”, is automatically applied at the beginning of the **next** period. Note that there is no interrupt at the beginning of the first PWM Period. This mode is suitable for PWM audio encoding.
4. **Simple GPIO**—In this mode the I/O pin operates as a GPIO pin. It can be specified as Input or Output, according to the programmable GPIO field. GPIO mode is mutually exclusive of modes 1 through 3 (listed above). In GPIO mode, modes 5 through 6 (listed below) remain available.

5. **CPU Timer**—The I/O pin is not used in this mode. Once enabled, the counters run until they reach a programmed Terminal Count. When this occurs, an interrupt can be generated to the CPU. This Timer mode can be used simultaneously with the Simple GPIO mode.
6. **Watchdog Timer**—This is a special CPU Timer mode, available only on Timer 0. The user must enable the Watchdog Timer mode, which is not active upon reset. The Terminal Count value is programmable. If the counter is allowed to expire, a full MPC5200B reset occurs. To prevent the Watchdog Timer from expiring, software must periodically write a specific value to a specific register (in Timer 0). This causes the counter to reset.

### 7.4.3 Programming Notes

Programmers should observe the following notes:

1. Intermediate values of the Timer internal counters are **not** readable by software.
2. The Stop_Cont bit operates differently for different modes. In general, this bit controls whether the Timer halts at the end of a current mode, or resets and continues with a repetition of the mode. See the Bit Description for precise operation.
3. The Timer_MS field operates somewhat as a Global Enable. If it is zero, then all Timer modes are disabled and internal counters are reset. See the Bit Descriptions for more detail.
4. There is a CE (Counter Enable) bit that operates somewhat independently of the Timer_MS field. This bit controls the Counter for CPU Timer or Watchdog Timer modes only. See the Bit Descriptions to understand the operation of these bits across the various modes.

### 7.4.4 GPT Registers

Each GPT uses 4 32-bit registers. These registers are located at an offset from MBAR of 0x0600. Register addresses are relative to this offset. Therefore, the actual register address is: MBAR + 0x0600 + register address.

Hyperlinks to the Interrupt Controller registers are provided below:

- GPT0–GPT7 Enable and Mode Select Registers (0x0600, 0x0620, 0x0630, 0x0640, 0x0650, 0x0660, 0x0670)
- GPT0–GPT7 Counter Input Registers (0x0604, 0x0614, 0x0624, 0x0634, 0x0644, 0x0654, 0x0664, 0x0674)
- GPT0–GPT7 PWM Configuration Registers 0x0608, 0x0618, 0x0628, 0x0638, 0x0648, 0x0658, 0x0668, 0x0678)
- GPT0–GPT7 Status Registers (0x060C. 0x061C, 0x062C, 0x063C, 0x064C, 0x065C, 0x066C, 0x067C)

### 7.4.4.1 GPT0–GPT7 Enable and Mode Select Registers

Address MBAR + 0x0600, 0x0610, 0x0620, 0x0630, 0x0640, 0x0650, 0x0660, 0x0670

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | OCPW | | | | | | | | Reserved | | OCT | | Reserved | | ICT | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | WDen | Reserved | | CE | Rsvd | Stop_Cont | Open_Drn | IntEn | Reserved | | GPIO | | Rsvd | Timer_MS | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-45. GPT0–GPT7 Enable and Mode Select Registers**

**Table 7-48. GPT0–GPT7 Enable and Mode Select Register Field Descriptions (Sheet 1 of 3)**

| Bit | Name | Description |
|---|---|---|
| 0:7 | OCPW | Output Compare Pulse Width—Applies to OC Pulse types only. This field specifies the number of IP bus clocks (non-prescaled) to create a short output pulse at each Output Event. This pulse is generated at the end of the OC period and overlays the next OC period (rather than adding to the period).<br>**Note:** This field is alternately used as the Watchdog reset field if Watchdog Timer mode is enabled. |
| 8:9 | — | Reserved |
| 10:11 | OCT | Output Compare Type—describes action to occur at each output compare event, as follows:<br>00=Special case, output is immediately forced low without respect to each output compare event.<br>01=Output pulse highs, initial value is low (OCPW field applies).<br>10=Output pulses low, initial value is high (OCPW field applies).<br>11=Output toggles.<br>GPIO modalities can be used to achieve an initial output state prior to enabling OC mode. It is important to move directly from GPIO output mode to OC mode and not to pass through the Timer_MS=000 state.<br>To prevent the Internal Timer Mode from engaging during the GPIO state, CE bit should be held low during the configuration steps.<br>GPIO initialization is needed when presetting the I/O to 1 in conjunction with a simple toggle OCT setting.<br>**Note:** For Stop Mode operation (see Stop_Cont bit below) it is necessary to pass through the mode_sel = 0 state to restart the output compare counters with their programmed values. See prescale and count fields in Table 7-49. |
| 12:13 | — | Reserved |
| 14:15 | ICT | Input Capture Type—describes the input transition type required to trigger an input capture event, as follows:<br>00=Any input transition causes an IC event.<br>01=IC event occurs at input rising edge.<br>10=IC event occurs at input falling edge.<br>11=IC event occurs at any input pulse (i.e., at 2nd input edge).<br>**BE AWARE:** For ICT=11 (pulse capture), status register records only the pulse width. |

**Table 7-48. GPT0–GPT7 Enable and Mode Select Register Field Descriptions (Sheet 2 of 3)**

| Bit | Name | Description |
|---|---|---|
| 16 | WDen | Watchdog enable—bit enables watchdog operation. A timer expiration causes an internal MPC5200B reset. Watchdog operation requires the Timer_MS field be set for internal timer mode and the CE bit to be set high.<br>In this mode the OCPW byte field operates as a watchdog reset field. Writing A5 to the OCPW field resets the watchdog timer, preventing it from expiring. As long as the timer is properly configured, the watchdog operation continues.<br>This bit (and functionality) is implemented only for Timer 0. 1 = enabled |
| 17:18 | — | Reserved |
| 19 | CE | Counter Enable—bit enables or resets the internal counter during Internal timer modes only. CE must be high to enable these modes. If low, counter is held in reset.<br>This bit is secondary to the timer mode select bits (Timer_MS). If Timer_MS is1XX, internal timer modes are enabled. CE can then enable or reset the internal counter without changing the Timer_MS field.<br>GPIO operation is also available in this mode. 1 = enabled |
| 20 | — | Reserved |
| 21 | Stop_Cont | Stop Continuous—Applies to multiple modes, as follows:<br>0 = Stop<br>1 = Continuous<br>• IC mode<br>Stop operation—At each IC event, counter is reset.<br>Continuous operation—counter is not reset at each IC event.<br>Effect is to create Status count values that are cumulative between Capture events. If the special Pulse Mode Capture type is specified, the Stop_Cont bit is not used, operation fixed as if it were Stop.<br>• OC mode<br>Stop operation—Counter resets and stops at first OC event. Note: Software needs to pass through Timer_MS=000 state to restart timer.<br>Continuous operation—counter resets and continues at each OC event.<br>Effect to is create back-to-back periodic OC events.<br>**BE AWARE**—In this mode the polarity of Stop_cont is reversed. Also, in Stop Mode, the output event falsely retriggers at the expiration of the prescale count.<br>This means the software has to service and output event prior to the prescale expiring. Service is defined as programming mode_sel field to 0, which causes the programmed prescale and count values to be reset.<br>• PWM mode<br>Bit not used, operation is always Continuous.<br>• CPU Timer mode<br>Stop operation—On counter expiration, Timer waits until Status bit is cleared by passing through Timer_MS=000 state before beginning a new cycle.<br>Continuous operation—On counter expiration, Timer resets and immediately begin a new cycle.<br>Effect is to generate fixed periodic timeouts.<br>• WatchDog Timer and GPIO modes<br>Bit not used. |
| 22 | Open_Drn | Open Drain<br>0 = Normal I/O<br>1 = Open Drain emulation—affects all modes that drive the I/O pin (GPIO, OC, & PWM). Any output “1” is converted to a tri-state at the I/O pin. |

**Table 7-48. GPT0–GPT7 Enable and Mode Select Register Field Descriptions (Sheet 3 of 3)**

| Bit | Name | Description |
|---|---|---|
| 23 | IntEn | Enable interrupt—enables interrupt generation to the CPU for all modes (IC, OC, PWM, and Internal Timer). IntEn is not required for watchdog expiration to create a reset. 1 = enabled |
| 24:25 | — | Reserved |
| 26:27 | GPIO | GPIO mode type. Simple GPIO functionality that can be used simultaneously with the Internal Timer mode. It is not compatible with IC, OC, or PWM modes, since these modes dictate the usage of the I/O pin.<br>0x=Timer enabled as simple GPIO input<br>10=Timer enabled as simple GPIO output, value=0<br>11=Timer enabled as simple GPIO output, value=1 (tri-state if Open_Drn=1)<br>While in GPIO modes, internal timer mode is also available. To prevent undesired timer expiration, keep the CE bit low. |
| 28 | — | Reserved |
| 29:31 | Timer_MS | Timer Mode Select (and module enable).<br>000=Timer module not enabled. Associated I/O pin is in input state. All Timer operation is completely disabled. Control and status registers are still accessible. This mode should be entered when timer is to be re-configured, except where the user does not want the I/O pin to become an input.<br>001=Timer enabled for input capture.<br>010=Timer enabled for output compare.<br>011=Timer enabled for PWM.<br>1xx=timer enabled for simple GPIO. Internal timer modes available. CE bit controls timer counter. |

### 7.4.4.2 GPT0–GPT7 Counter Input Registers

Address MBAR + 0x0614, 0x0624, 0x0634, 0x0644, 0x0654, 0x0664, 0x0674

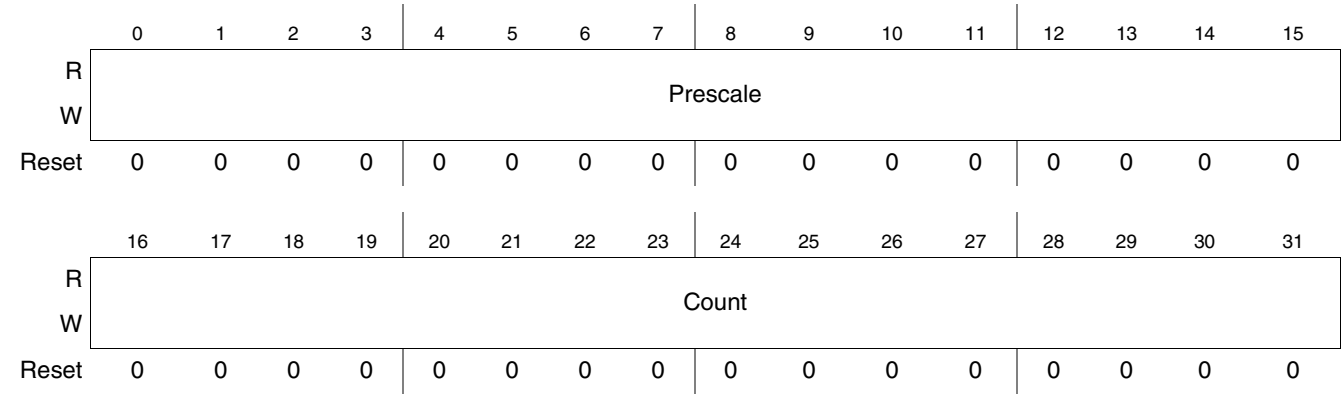



**Figure 7-46. GPT0–GPT7 Counter Input Registers**

**Table 7-49. GPT0–GPT7 Counter Input Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:15 | Prescale | Prescale amount applied to internal counter (in IP bus clocks).<br>**BE AWARE**—The prescale field should be written prior to enabling any timer mode. A prescale of 0x0001 means one IP bus clock per count increment. If prescale is 0 when any timer mode is started, it results in an effective prescale of 64K. The counter will immediately begin and an output event will occur with the 64K prescale, rather than the desired value. |
| 16:31 | COUNT | Sets number of prescaled counts applied to reference events, as follows:<br>IC—Field has no effect, internal counter starts at 0.<br>OC—Number of prescaled counts counted before creating output event.<br>PWM—Number of prescaled counts defining the PWM output period.<br>Internal Timer—Number of prescaled counts counted before timer (or watchdog) expires.<br>**Note:** Reading this register only returns the programmed value, intermediate values of the internal counter are not available to software. |

### 7.4.4.3 GPT0–GPT7 PWM Configuration Registers

Address MBAR + 0x0608, 0x0618, 0x0628, 0x0638, 0x0648, 0x0658, 0x0678

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | WIDTH | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | PWMOP | Reserved | | | | | | | LOAD |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-47. GPT0–GPT7 PWM Configuration Registers**

**Table 7-50. GPT0–GPT7 PWM Configuration Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:15 | WIDTH | PWM only. Defines ON time for output in prescaled counts. Similar to count value, which defines the period. ON time overlays the period time.<br>If WIDTH = 0, output is always OFF.<br>If WIDTH exceeds count value, output is always ON.<br>ON and OFF polarity is set by the PWMOP bit. |
| 16:22 | — | Reserved |
| 23 | PWMOP | Pulse Width Mode Output Polarity—Defines PWM output polarity for OFF time. Opposite state is ON time polarity. PWM cycles begin with ON time. |
| 24:30 | — | Reserved |
| 31 | LOAD | Bit forces immediate period update. Bit auto clears itself. A new period begins immediately with the current count and width settings.<br>If LOAD = 0, new count or width settings are not updated until end of current period.<br>**Note:** Prescale setting is not part of this process. Changing prescale value while PWM is active causes unpredictable results for the period in which it was changed. The same is true for PWMOP bit. |

### 7.4.4.4 GPT0–GPT7 Status Registers

This is a read-only register.

Address MBAR + 0x061C, 0x062C, 0x063C, 0x064C, 0x065C, 0x066C, 0x067C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | CAPTURE | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Rsvd | OVF | | | Reserved | | | PIN | Reserved | | | | TEXP | PWMP | COMP | CAFT |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 7-48. GPT0–GPT7 Status Registers**

**Table 7-51. GPT0–GPT7 Status Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:15 | Capture | Read of internal counter, latch at reference event. This is pertinent only in IC mode, in which case it represents the count value at the time the Input Event occurred. Capture status does not shadow the internal counter while an event is pending, it is updated only at the time the Input Event occurs.<br>**Note:** If ICT is set to 11, which is Pulse Capture Mode, the Capture value records the width of the pulse. Also, the Stop_Cont bit is irrelevant in Pulse Capture Mode, operation is as if Stop_Cont were 0. |
| 16 | — | Reserved |
| 17:19 | OVF | Represents how many times internal counter has rolled over. This is pertinent only during IC mode and would represent an extremely long period of time between Input Events. However, if Stop_Cont = 1 (indicating cumulative reporting of Input Events), this field could come into play.<br>**Note:** This field is cleared by any “sticky bit” status write in the 4 bit fields below (28, 29, 30, 31). |
| 20:22 | — | Reserved |
| 23 | PIN | Registered state of the I/O PIN (all modes). The IP bus Clock registers the state of the I/O input. Valid, even if Timer is not enabled. |
| 24:27 | — | Reserved |
| 28 | TEXP | Timer Expired in Internal Timer mode. Cleared by writing 1 to this bit position. Also cleared if Timer_MS is 000 (i.e., Timer not enabled). See Note. |
| 29 | PWMP | PWM end of period occurred. Cleared by writing 1 to this bit position. Also cleared if Timer_MS is 000 (i.e., Timer not enabled). See Note. |
| 30 | COMP | OC reference event occurred. Cleared by writing 1 to this bit position. Also cleared if Timer_MS is 000 (i.e., Timer not enabled). See Note. |
| 31 | CAPT | IC reference event occurred. Cleared by writing 1 to this bit position. Also cleared if Timer_MS is 000 (i.e., Timer not enabled). See Note. |

**Note:** To clear any of these bits, it is necessary to clear **all** of them. An F must be written to bits 28:31.

## 7.5 Slice Timers

Two Slice Timers are included to provide shorter term periodic interrupts. Each timer consists of a 24-bit counter with **no** prescale. Running off the IP bus clock, each timer can generate interrupts from 7.75uS to 508mS in 30nS steps (based on 33MHz IP bus clock). The counters count up from zero and expire/interrupt when they reach the programmed terminal count. They can be configured to automatically reset to zero and resume counting or wait until the Status/Interrupt is serviced before beginning a new cycle.

The current count value can be read without disturbing the count operation. Each Slice Timer has a Status bit to indicate the Timer has expired. If enabled, a CPU interrupt is generated at count expiration. Each Timer has a separate Interrupt. Slice Timer 0 represents CPU interrupt Critical Level 2 and Slice Timer 1 represents Main Level 0 (which is hardwired to the core_smi pin). Clearing the Status and/or Interrupt is accomplished by writing 1 to the Status bit, or disabling the Timer entirely with the Timer Enable (TE) bit.

As a safety, the Timer does not count until a Terminal Count value of greater than 255 is programmed into it. Also, writing a Terminal Count value of 0 is converted to all 1s, resulting in a maximum duration timeout.

### 7.5.1 SLT Registers

There are two SLT Timers. Each one uses four 32-bit registers. These registers are located at an offset from MBAR of 0x0700. Register addresses are relative to this offset. Therefore, the actual register address is: MBAR + 0x0700 + register address.

Hyperlinks to the Interrupt Controller registers are provided below:

- SLT0–SLT1 Terminal Count Registers (0x0700, 0x0710)
- SLT0–SLT1 Control Field Registers (0x0704, 0x0714)
- SLT0–SLT1 Count Value Registers (0x0708, 0x0718) read only
- SLT0–SLT1 Timer Status Registers (0x070C, 0x071C) read only

### 7.5.1.1 SLT0–SLT1 Terminal Count Registers

Address MBAR + 0x0700, 0x0710

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | Terminal Count | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Terminal Count | | | | | | | | | | | | | | | |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Figure 7-49. SLT0–SLT1 Terminal Count Registers**

**Table 7-52. SLT0– SLT1 Terminal Count Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | — | Reserved |
| 8:31 | Terminal Count | The user programs this register to set the Terminal Count value to be used by the Timer.<br>This register can be updated even if the Timer is running, the new value takes effect immediately. The internal counter is compared to this register to determine if Terminal Count has been reached.<br>**Note:** The Timer will not begin counting until a value greater than 255 is programmed into the Terminal Count Register. A value less than 255 will essentially suspend the Timer.<br>Writing a value of zero to this register is considered invalid and will be converted to all ones, creating a maximum duration count period.<br>Defaults at reset: TerminalCount will default to all ones, all other control bits will default to zero. |

### 7.5.1.2 SLT0–SLT1 Control Registers

Address MBAR + 0x0704, 0x0714

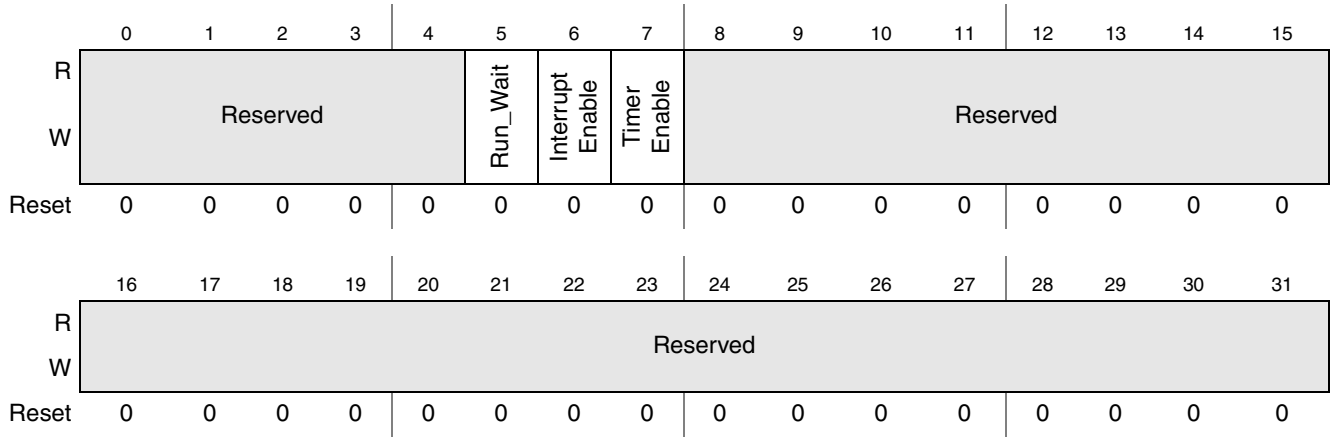



**Figure 7-50. SLT0–SLT1 Control Field Registers**

**Table 7-53. SLT0–SLT1 Control Field Register Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:4 | — | Reserved |
| 5 | Run_ Wait | A high indicates the Timer should run continuously while enabled. When the Timer counter reaches terminal count it immediately resets to 0 and resumes counting. If the Run/Wait bit is set low, the Timer Counter expires, but then waits until the Timer is cleared (either by writing 1 to the status bit or by disabling and re-enabling the Timer), before resuming operation. |
| 6 | Interrupt Enable | CPU Interrupt is generated only if this bit is high. This bit does **not** affect operation of the Timer Counter or Status Bit registers. |
| 7 | Timer Enable | While this bit is high the Timer operates normally, while low the Timer is reset and remains idle. |
| 8:32 | — | Reserved |

### 7.5.1.3 SLT0–SLT1 Count Value Registers

Address MBAR + 0x0708, 0x0718

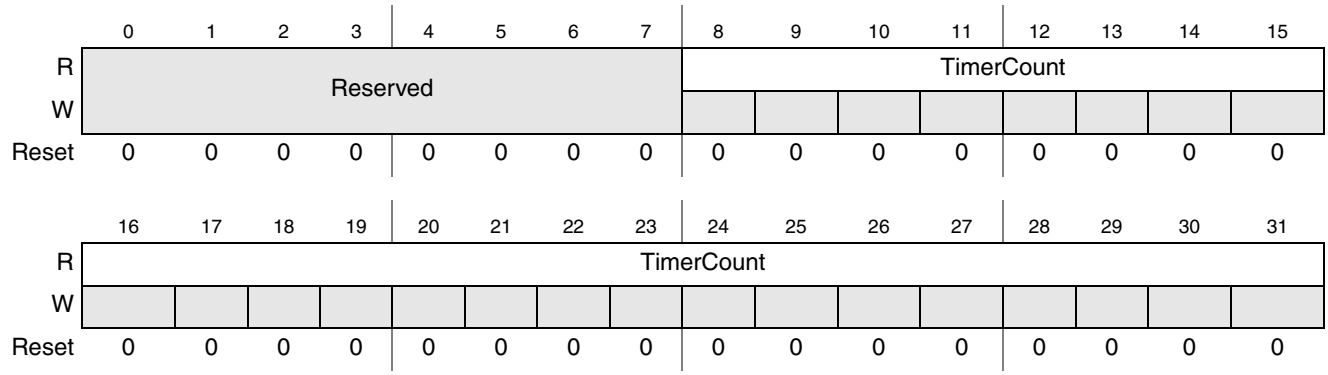



**Figure 7-51. SLT0–SLT1 Count Value Registers**

**Table 7-54. SLT0– SLT1 Count Value Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | — | Reserved |
| 8:31 | Timer Count | Provides current state of the Timer counter. This register does not change while a read is in progress, but the actual Timer counter continues unaffected. |

### 7.5.1.4 SLT0–SLT1 Timer Status Registers

Address MBAR + 0x070C, 0x071C

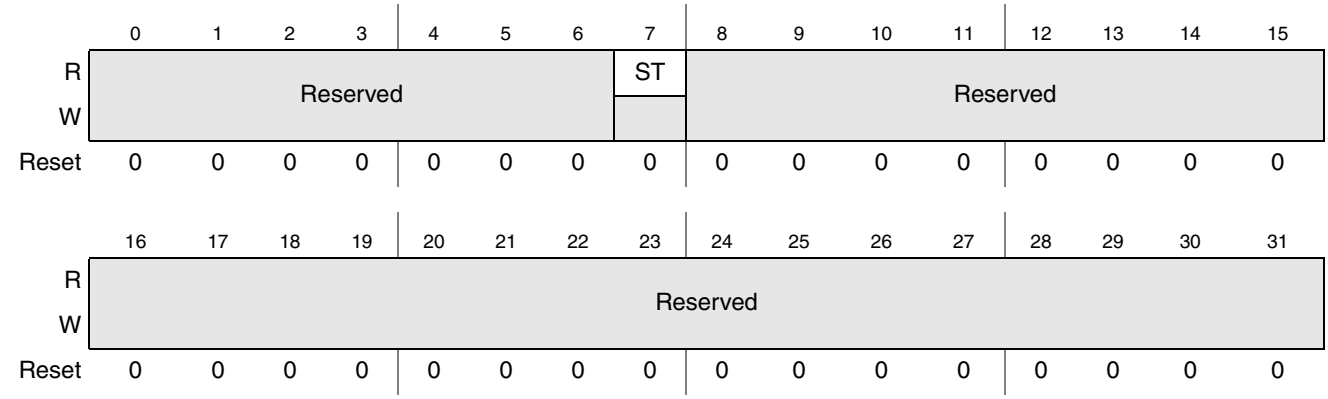



**Figure 7-52. SLT0–SLT1 Timer Status Registers**

**Table 7-55. SLT0–SLT1 Timer Status Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7 | ST | This status bit goes high whenever the Timer has reached Terminal Count. The bit is cleared by writing 1 to its bit position. If Interrupts are enabled, clearing this status bit also clears the interrupt. |
| 8:31 | — | Reserved |

## 7.6 Real-Time Clock

The Real-Time Clock (RTC) uses an external 32 kHz crystal to provide:

- Alarm
- Stop-watch
- Periodic interrupts
  - — Minute
  - — Second
  - — Midnight rollover (day)

The clock runs as long as power is maintained and the crystal is running, regardless of MPC5200B power-down states.

The RTC module has the following features:

- Gull clock features
- Minute countdown timer—provides 256-minute capability, slightly over 4 hours
- Programmable alarm—operates on time of day only, not related to calendar
- Periodic interrupts for:
  - — 1 second
  - — 1 minute
  - — 1 day—operates only at midnight rollover
- Calendar features:
  - — Day
  - — Date
  - — Year
- Crystal support (32.768 kHz only)

RTC registers are writable, letting time and date be updated. If software enabled, RTC operates during all MPC5200B power-down modes. At a reset, control registers are put in a default state such that no interrupts generate until software enabled.

The RTC has two CPU interrupt signals connected to the Interrupt Controller, they are:

- RTC_Periodic, which is Main Level 5 fed by the Day, Minute, or Second sources.
- RTC_Stopwatch, which is Main Level 6 fed by the Alarm or Stopwatch sources.

Periodic interrupts are separately enabled by control bits, and a global enable must be asserted to allow any of the periodic sources to generate a CPU interrupt. Clearing Periodic interrupts is accomplished by writing 1 to the appropriate status bit.

Stopwatch and Alarm interrupts are enabled simply by initiating the function. In the Stopwatch case, this means starting the Stopwatch, in the Alarm case, this means enabling the Alarm. Clearing Stopwatch or Alarm interrupts is accomplished by writing 1 to the appropriate status bit.

Either of the RTC interrupts to the CPU can be used to awaken the MPC5200B from any power down mode.

## 7.6.1 Real-Time Clock Signals

**Table 7-56. Real-Time Clock Signals**

| Signal | I/O | Definition |
|---|---|---|
| RTC_XTAL_IN | I | Real-time Clock External Crystal/External Clock Input |
| RTC_XTAL_OUT | O | Real-time Clock External Crystal |

Figure 7-53 shows a suggested circuit using an Epson® MC-405 32.768KHz quartz crystal oscillator.

**NOTE**

External component values are highly dependent on the crystal. These values will be different for different brands of crystals.

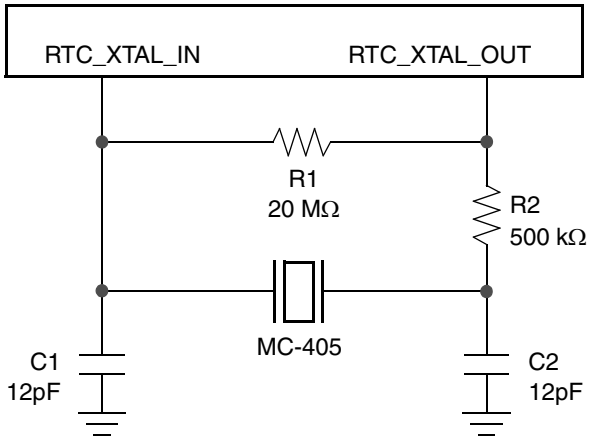



**Figure 7-53. Diagram—Suggested Crystal Oscillator Circuit**

## 7.6.2 Programming Note

Accesses to the RTC control registers are performed on the IP bus clock domain, but the RTC itself runs on the (much) slower 32KHz crystal domain. When software initiates a setting of the Time and/or Date, it must be realized that many IP bus clocks may go by before the setting actually takes effect. If this is a system concern then it is recommended that software poll the Time and/or Date Status fields to confirm the setting has occurred. This requires some careful bit manipulation of the expected status versus the written control values, particularly if the output status is designated as 12-Hour format (input control format is always 24-Hour).

It should be noted that updates to the RTC control registers, such as time and date set, must be synchronized with the 32 kHz clock domain. It can take four 32KHz clock cycles for this synchronizing hand shake to complete. Multiple time/date updates made within this four clock synchronizing period may not be properly accepted by the RTC logic.

### 7.6.3 RTC Interface Registers

RTC uses 8 32-bit registers. These registers are located at an offset from MBAR of 0x0800. Register addresses are relative to this offset. Therefore, the actual register address is: MBAR + 0x0800 + register address.

Hyperlinks to the Interrupt Controller registers are provided below:

- RTC Time Set Register (0x0800)
- RTC Data Set Register (0x0804)
- RTC New Year and Stopwatch Register (0x0808)
- RTC Alarm and Interrupt Enable Register (0x080C)
- RTC Current Time Register (0x0810), read-only
- RTC Current Date Register (0x0814), read-only
- RTC Alarm and Stopwatch Interrupt Register (0x0818), read-only
- RTC Periodic Interrupt and Bus Error Register (0x081C), read-only
- RTC Test Register/Divides Register (0x0820)

### 7.6.3.1 RTC Time Set Register

Address MBAR + 0x0800

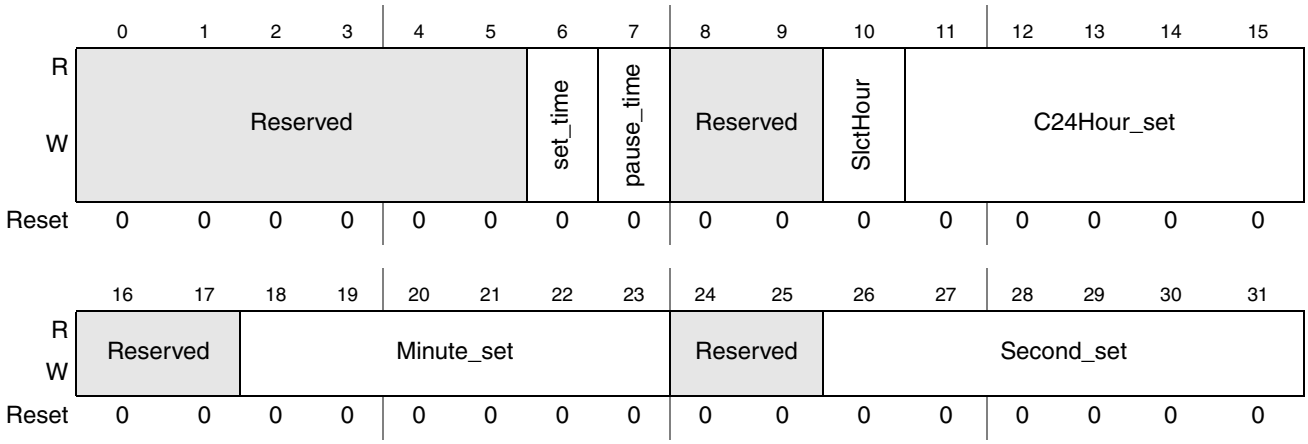

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
R
W
Reserved
set_time
pause_time
Reserved
SlctHour
C24Hour_set
Reset 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
R
W
Reserved
Minute_set
Reserved
Second_set
Reset 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

**Figure 7-54. RTC Time Set Register**

**Table 7-57. RTC Time Set Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:5 | — | Reserved |
| 6 | set_time | A bit used in conjunction with pause_time bit (below) to cause a new time to be programmed into the RTC. After a proper software sequence, the values in the *_set fields below are loaded.<br>The proper software sequence is:<br>1. Write register with pause_time 1 and set_time 0<br>2. Write register with pause_time 1 and set_time 1<br>3. Write register with pause_time 1 and set_time 0<br>4. Write register with pause_time 0 and set_time 0<br>At completion of Step 4, RTC is updated with the new time.<br>The C24Hour_set, Minute_set, and the Second_set fields should remain consistent values throughout the four steps (i.e., at the desired new time values).<br>**Note:** Read-modify-write operations may disrupt this procedure, it is advised that four simple writes occur. Byte writes to this byte are also acceptable. |
| 7 | pause_time | Used with set_time above to perform time update. Must be zero for normal operation. |
| 8:9 | — | Reserved |
| 10 | SlctHour | This bit determines the hour output format.<br>• low bit = 24-hour format<br>• high bit = 12-hour format with AM/PM<br>**Note:** This bit does NOT affect time set procedure, it only affects how the Hour Status field is presented. |
| 11:15 | C24Hour_set | Hour in 24-hour format written in RTC after successful state machine transition by set_time and pause_time bits.<br>**Note:** This field is always written with 24-Hour format, it is NOT affected by SlctHour bit above. |
| 16:17 | — | Reserved |
| 18:23 | Minute_set | Minute written in RTC after successful state machine transition by set_time and pause_time bits. |
| 24:25 | — | Reserved |
| 26:31 | Second_set | Second written in RTC after successful state machine transition by set_time and pause_time bits. |

### 7.6.3.2 RTC Date Set Register

Address MBAR + 0x0804

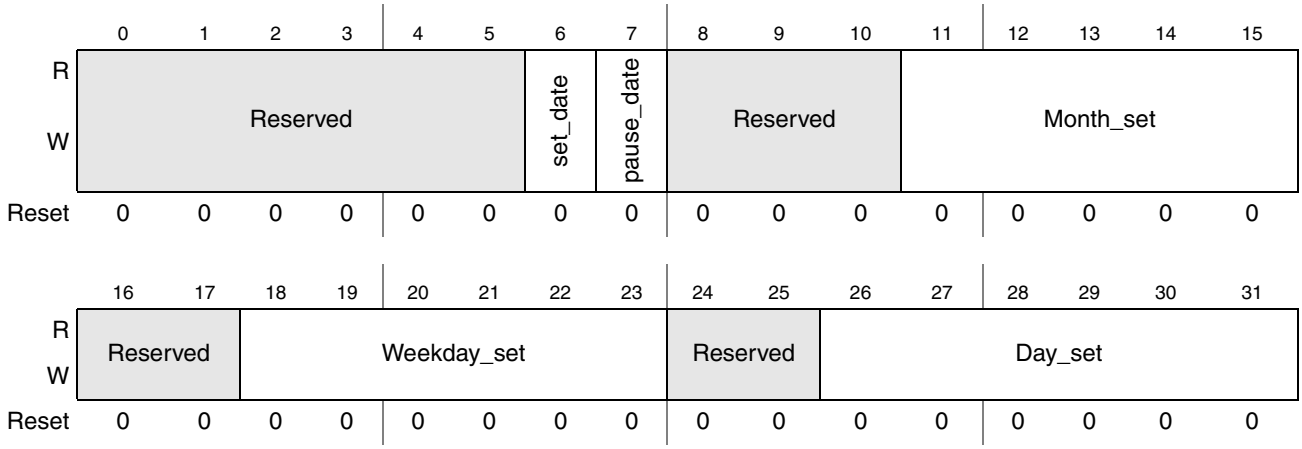



**Figure 7-55. RTC Data Set Register**

**Table 7-58. RTC Date Set Field Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:5 | — | Reserved |
| 6 | set_date | Operation of pause_date and set_date is similar to pause_time and set_time described in the time set register. |
| 7 | pause_date | Used with set_date above to perform date update. Must be zero for normal operation. |
| 8:10 | — | Reserved |
| 11:15 | Month_set | New month written in RTC after successful state machine transition by set_date and pause_date bits. Actually the lower 4 bits is used |
| 16:17 | — | Reserved |
| 18:23 | Weekday_set | New weekday written in RTC after state machine transition by set_date and pause_date bits. 1 = Monday; 7 = Sunday. Actually the lower 3 bits is used. |
| 24:25 | — | Reserved |
| 26:31 | Date_set | New date written in RTC after state machine transition by set_date and pause_date bits. Actually the lower 5 bits is used.<br>**Note:** Year_set in the following register is also part of the date set function. |

### 7.6.3.3 RTC New Year and Stopwatch Register

Address MBAR + 0x0808

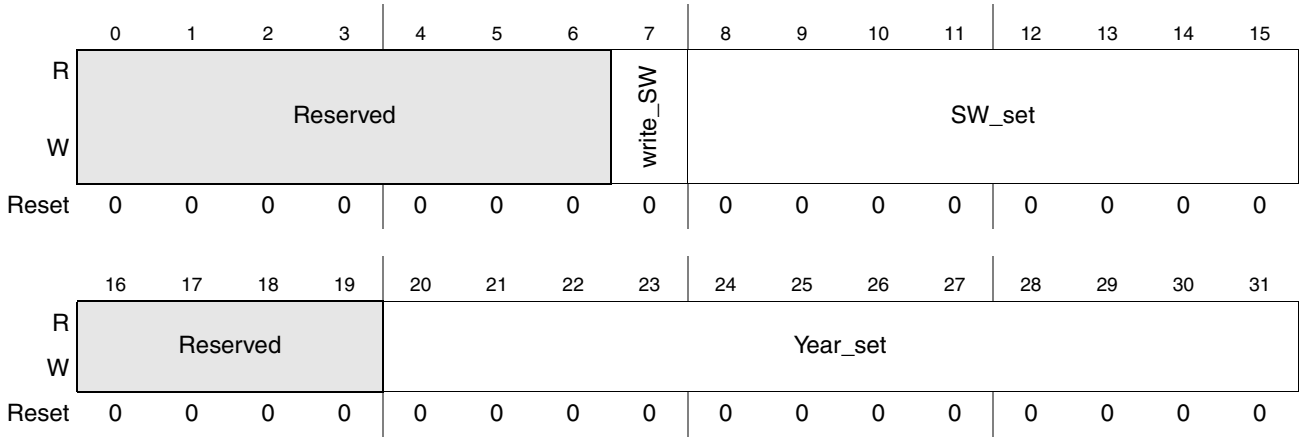



**Figure 7-56. RTC New Year and Stopwatch Register**

**Table 7-59. RTC New Year and Stopwatch Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7 | write_SW | Typical stopwatch operation is to write initial value into 8-bit wide SW_set and assert write_SW bit. The write_SW bit is immediately auto cleared, but it triggers the stopwatch minute countdown to begin. |
| 8:15 | SW_set | Number of minutes to be written into stopwatch. Max is 255, a little over 4 hours. |
| 16:19 | — | Reserved |
| 20:31 | Year_set | New year written in RTC after successful state machine transition by set_date and pause_date bits. **Note:** This is part of date set function in the previous register. |

### 7.6.3.4 RTC Alarm and Interrupt Enable Register

Address MBAR + 0x0800, 0x080C

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
R
W
Reserved
Alm_enable
Reserved
Alm_24H_set
Reset 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
R
W
Reserved
Alm_Min_set
Reserved
MPEb
IntEn_day
IntEn_min
IntEn_sec
Reset 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0

**Figure 7-57. RTC Alarm and Interrupt Enable Register**

**Table 7-60. RTC Alarm and Interrupt Enable Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7 | Alm_enable | Alarm Enable bit for once-a-day Alarm. If high, Alarm status/interrupt operation is enabled. If low, Alarm setting is not compared to time of day. |
| 8:10 | — | Reserved |
| 11:15 | Alm_24Hset | Hour setting (in 24 hour format) to be compared to time of day for the purpose of generating Alarm Status/Interrupt. Can be written at any time. |
| 16:17 | — | Reserved |
| 18:23 | Alm_Min_set | Minute setting to be compared to time of day for the purpose of generating Alarm Status/Interrupt. Can be written at any time. |
| 24:27 | — | Reserved |
| 28 | MPEb | Master Periodic Enable bar. Must be written low after reset to allow periodic interrupts. |
| 29 | IntEn_day | Enable bit of periodic interrupts at midnight rollover. |
| 30 | IntEn_min | Enable bit of periodic interrupts at minute rollover. |
| 31 | IntEn_sec | Enable bit of periodic interrupts at second rollover. |

**Note:** The Interrupt enable bits (28, 29, 30, 31) control the Periodic Interrupt coming from the RTC. The separate Stopwatch/Alarm Interrupt signal does not have a specific interrupt enable bit. An Alarm interrupt is automatically generated if Alarm is enabled and the Alarm setting matches time of day. Similarly, a Stopwatch expiration, which shares the Alarm interrupt signal, automatically occurs once the Stopwatch is initiated and the Stopwatch counter expires.

### 7.6.3.5 RTC Current Time Register

This is a read-only register.

Address MBAR + 0x0810

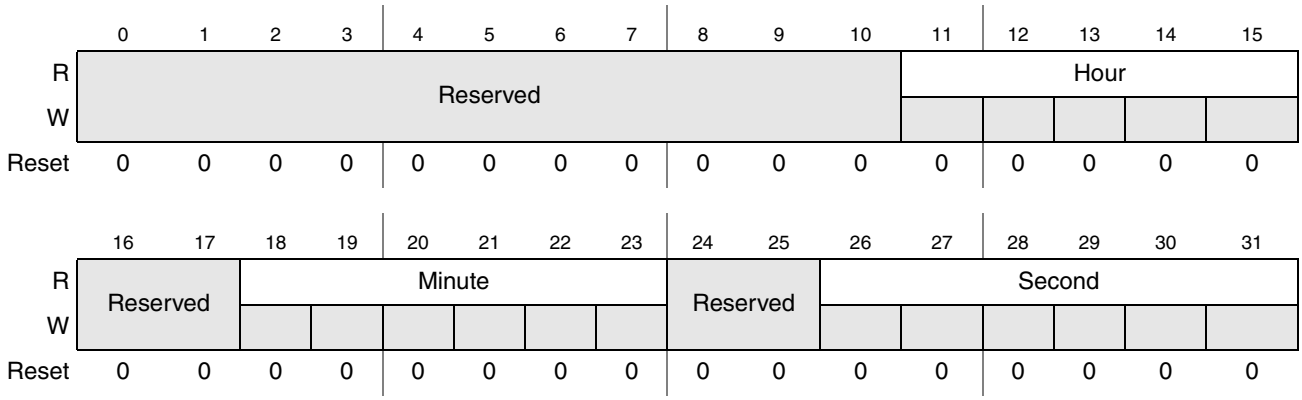



**Figure 7-58. RTC Current Time Register**

**Table 7-61. RTC Current Time Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:10 | — | Reserved |
| 11:15 | Hour | Hour format can be either 24-hour or 12-hour with AM/PM.<br>If 24-hour format is selected (SlctHour low in Reg 0), the whole 5-bit hour field designates current time in 24-hour format.<br>If 12-hour format is selected (SlctHour high in Reg 0), the MSB of hour field indicates:<br>• Hour[0]=0: AM,<br>• Hour[0]=1: PM and<br>• Hour[1:4] designates current time in 12-hour format. |
| 16:17 | — | Reserved |
| 18:23 | Minute | Shows minutes in current time. |
| 24:25 | — | Reserved |
| 26:31 | Second | Shows seconds in current time. |

### 7.6.3.6 RTC Current Date Register

This is a read-only register.

Address MBAR + 0x0814

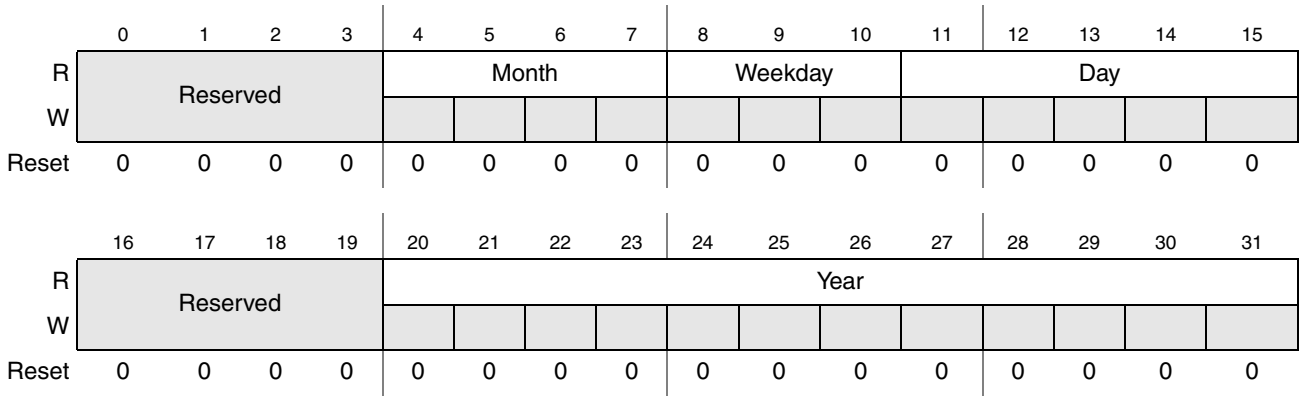



**Figure 7-59. RTC Current Date Register**

**Table 7-62. RTC Current Date Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:7 | Month | Shows current month. 1 = January; 12 = December |
| 8:10 | Weekday | Indicates day of week. (Monday = 1, Sunday = 7) |
| 11:15 | Date | Shows current date. Calendar feature is implemented, therefore, day rollover at the end of month including February (and Leap Years) is automatic. |
| 16:19 | — | Reserved |
| 20:31 | Year | Shows current year. Max is 4052. |

### 7.6.3.7 RTC Alarm and Stopwatch Interrupt Register

This is a read-only register.

Address MBAR + 0x0818

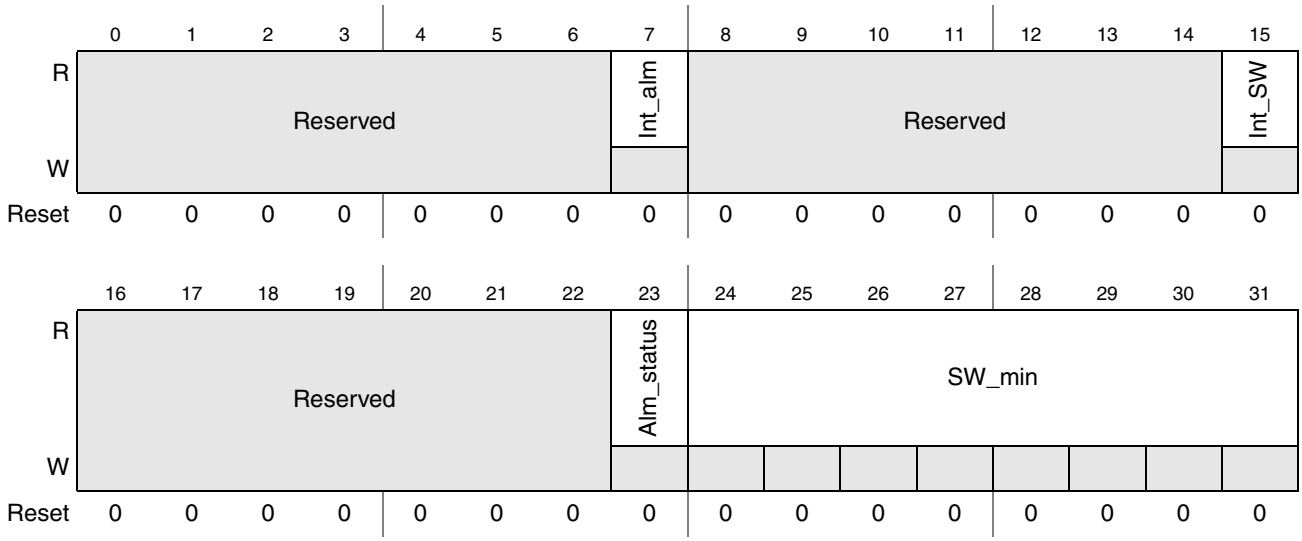



**Figure 7-60. RTC Alarm and Stopwatch Interrupt Register**

**Table 7-63. RTC Alarm and Stopwatch Interrupt Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7 | Int_alm | Status bit indicating that enabled once-a-day Alarm has occurred (active high). Alarm interrupt has been activated. This bit and the Interrupt is cleared by writing 1 to this bit position.<br>**Note:** A Stopwatch interrupt, if also active, must be cleared before the interrupt signal to the CPU is negated. |
| 8:14 | — | Reserved |
| 15 | Int_SW | Status bit indicating that Stopwatch expiration has occurred (active high). Stopwatch interrupt has been activated. This bit and the Interrupt are cleared by writing 1 to this bit position.<br>**Note:** An Alarm interrupt, if also active, must be cleared before the interrupt signal to the CPU is negated. |
| 16:22 | — | Reserved |
| 23 | Alm_status | Status bit indicating that once-a-day Alarm has occurred. Same as Int_alm bit above except that clearing this bit does NOT clear the interrupt. |
| 24:31 | SW_min | Minutes remaining in stopwatch. |

### 7.6.3.8 RTC Periodic Interrupt and Bus Error Register

This is a read-only register.

Address MBAR + 0x081C

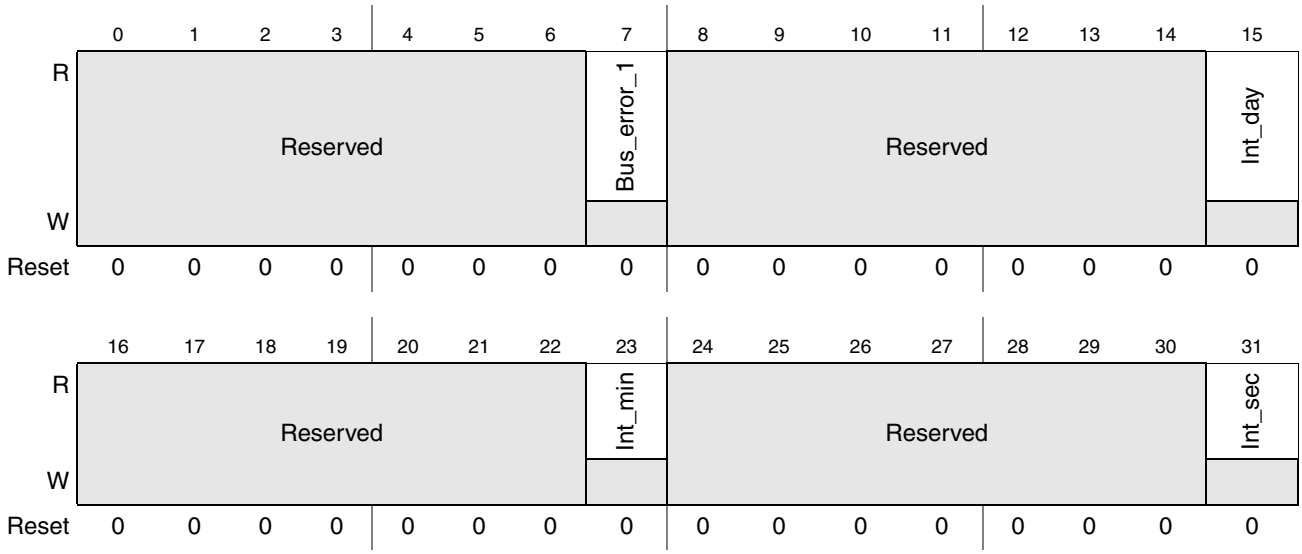



**Figure 7-61. RTC Periodic Interrupt and Bus Error Register**

**Table 7-64. RTC Periodic Interrupt and Bus Error Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7 | Bus_error_1 | Internal status register—If high, indicates software has attempted a write access to a read-only register in this module. No actual register contents are corrupted if this happens.<br>Cleared by writing 1 to this bit position. |
| 8:14 | — | Reserved |
| 15 | Int_day | Periodic interrupt at midnight. High indicates interrupt has occurred.<br>OR'd function of Int_day, Int_min and Int_sec produces RTC periodic interrupt to CPU interface.<br>Cleared by writing 1 to this bit position. |
| 16:22 | — | Reserved |
| 23 | Int_min | Periodic interrupt at each minute rollover. High indicates interrupt has occurred.<br>Cleared by writing 1 to this bit position. |
| 24:30 | — | Reserved |
| 31 | Int_sec | Periodic interrupt at each second rollover. High indicates interrupt has occurred.<br>Cleared by writing 1 to this bit position. |

### 7.6.3.9 RTC Test Register/Divides Register

This register is used during manufacturing test to expedite RTC testing and is not intended to be a user register. However, no protection from software access is provided.

Address MBAR + 0x0820

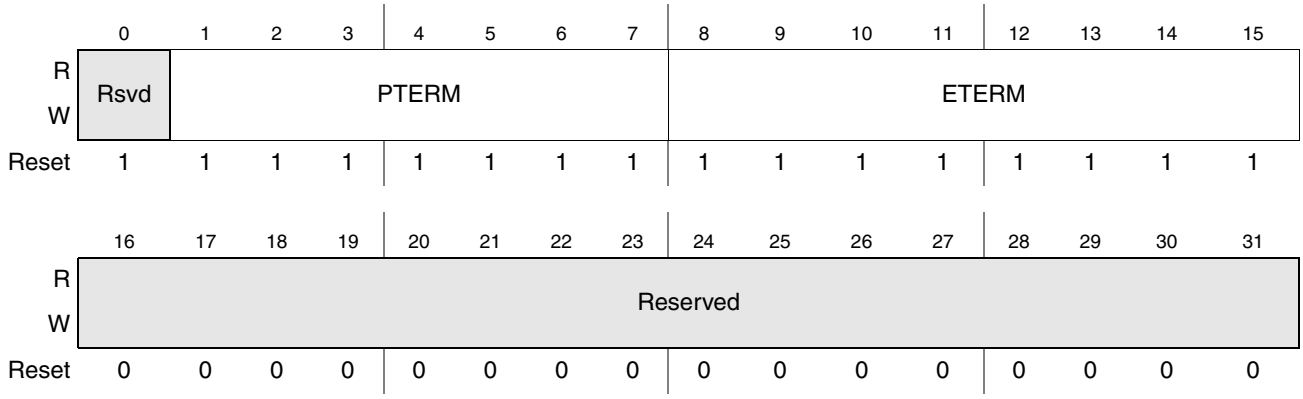



**Figure 7-62. RTC Test Register/Divides Register**

**Table 7-65. RTC Test Register/Divides Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | — | Reserved |
| 1:7 | PTERM | Prescale Termination value, the number of 32KHz clocks per 7-bit prescale counter. Default at reset is the maximum (and proper) value of 128 decimal. Any value lower than this causes the RTC to run fast. |
| 8:15 | ETERM | External Termination value, the number of prescaled counts per 8-bit external counter. Default at reset is the maximum (and proper) value of 256 decimal. Any value lower than this causes the RTC to run fast. |
| 16:31 | — | Reserved |

**Note:** The 32.768KHz crystal frequency is divided by PTERM, which is then divided by ETERM to produce a 1 second time interval. It is conceivable that a system might wish to adjust these values to produce a more locally accurate clock rate. However, be aware that these values are affected by reset. Therefore, any adjustment value must be stored and retrieved from non-volatile memory. Further, the adjustment could only increase the clock rate, not decrease it.

# Chapter 8
# SDRAM Memory Controller

## 8.1 Overview

The following sections are contained in this document:

- Terminology and Notation
- Features
  - Devices Supported
- Functional Description
  - External Signals (SDRAM Side)
  - Block Diagram
  - Transfer Size
  - Commands
- Operation
  - Power-Up Initialization
- Programming the SDRAM Controller
- Memory Controller Registers

## 8.2 Terminology and Notation

Synchronous DRAM devices (SDR-SDRAM, DDR-SDRAM) are organized internally as columns by rows by “banks”. Older type asynchronous DRAMs (FP, EDO) had rows and columns, but no internal banks. Historically, the word “bank” was often used to refer to the set of memory devices all activated for the same address range (same $\overline{\text{RAS}}$). To avoid confusion between these two meanings of “bank”, this document uses the term “bank” for the internal banks of an SDRAM device, and the term “space” to indicate the memory device(s) activated for a common address range (same $\overline{\text{CS}}$).

### 8.2.1 “Endian”-ness

Endian-ness is a source of seemingly endless confusion, yet it need not be. The source of the confusion usually seems to be that bit number and/or byte address are improperly equated with significance. In fact, bit number and byte address ***neither govern, nor imply***, significance.

- Significance can ***only*** exist within an ***arithmetic*** context. An arithmetic context can be explicit or implicit.
- An ***explicit*** arithmetic context is the scope of an arithmetic ***operator***, that is, the operand(s) and result(s).

- An ***implicit*** arithmetic context exists within any collection of bits representing an atomic arithmetic object, that is, a ***number***. Significance does ***not*** extend beyond the boundaries of the bit range.
- With a single exception, an arithmetic context, and therefore significance, can ***only*** exist within an ***execution*** context, that is, an abstract process or the actual hardware to which it is mapped. The single exception is an implicit context: A ***byte*** is an implicit arithmetic context.
- Within an atomic object bj[m:n], in an arithmetic context, the most significant bit(byte) is on the ***left*** (m), and the least significant bit(byte) is on the ***right*** (n), unless otherwise specified. The bit numbering and byte addressing order from left to right (ascending or descending) is ***strictly cosmetic***.

  Note that ":" in "m:n" is an arithmetic operator, and therefore m and n are arithmetic objects within the operator scope. (If they weren't, then the terms "ascending" and "descending" would be meaningless.)

  Note furthermore that the scope of the ":" operator does not include "obj": obj could be of a non-arithmetic type. One particular value (pattern of the bit range) of obj could represent "red"; another value might represent "cold". The bit patterns are ***enumerations*** of the legal values of obj; sometimes arithmetic operations on enumeration values are valid for the concepts they represent, sometimes not.

  An enumeration value is not an arithmetic context. An enumeration value is a representation of an object value; the nature of the object itself need not be numeric.

The enumeration value of a collection of bits (e.g. process variable) is only meaningful ***in the context*** of a process which manipulates those bits in a manner consistent with the concept they represent. (A process itself may be just a concept represented by a collection of bits manipulated (by a processing unit) in a manner consistent with the concept they represent.) And ***in the context*** of the concept they represent, bits and bytes may have significance.

But while transporting bits from one location to another, the hardware transport media almost never have any knowledge of the concepts represented by the data, or the contexts in which they are valid (this does not include protocol bits of the media, which may be added and stripped along the way). Nor is the transportation of data an execution context. Without knowledge of atom boundaries and significance (if any), the following convention is the *de facto* standard:

- "**Bit significance, byte address**": From every observation point in a system, the relative ***address order*** of bytes shall be maintained, and the relative ***significance*** of bits ***within*** each individual byte shall be maintained, ***as if*** they represented an 8 bit unsigned binary integer. This is the implicit arithmetic context of bytes. The "native" bit numbering and address significance order of different observers shall have ***no bearing*** on the byte address or bit significance order of visible data.

  Byte "swapping", the intentional transposition of bytes' relative addresses between a source and a destination to maintain inter-byte significance, is ***improper***.

  Bit "swizzling", the intentional renumbering of bit positions, is perfectly legal ***if necessary*** to maintain intra-byte bit significance or inter-byte address order. When necessary, it is required; when not necessary, it is prohibited.

To correctly join data path segments in accordance with this convention, the bit significance ***and byte addressing*** of each segment must be specified.

In this document, significance is always msb on the left, lsb on the right, if any significance relationship exists.

All multi-bit components of the internal XL bus are defined with bit numbers and byte addresses (if any) ***ascending*** from left to right: XLA[0:31], XLD[0:63]. The address of byte XLD[0:7] is a modulo 8 boundary, 8*n* (0x00, 0x08, 0x10, 0x18); the address of byte XLD[56:63] is a modulo 8 boundary plus offset 7, 8*n*+7 (0x07, 0x0F, 0x17, 0x1F).

All internal IP busses are defined with bit numbers ***descending*** from left to right: IPA[31:0], IPD[31:0]. The byte addresses of IPD[31:0] are defined ***ascending*** from left to right: IPD[31:24] is a modulo 4 address boundary, 4*n* (0x00, 0x04, 0x08, 0x0C); IPD[7:0] is a modulo 4 address boundary plus offset 3, 4*n*+3 (0x03, 0x07, 0x0B, 0x0F). IPA[31:0] correspond left-to-right with XLA[0:31]. IPD[31:0] correspond left-to-right with XLD[0:31] (XLA[29] == 0) or XLD[32:63] (XLA[29] == 1).

The Memory Controller registers are defined with byte addresses and ***bus*** bit numbers ***ascending*** from left to right; but object bit ***fields*** within the registers may have ***ascending*** or ***descending*** bit numbers. The numbering order of bits as a bus does not govern the numbering order of bits within a data object.

All external memory interface busses are defined with ***descending*** bit numbers: MEM_MA[12:0], MEM_MBA[1:0], MEM_MDQ[31:0], MEM_DQM[3:0], MEM_MDQS[3:0]. Byte addressing of MEM_MDQ[31:0], MEM_DQM[3:0], and MEM_MDQS[3:0] is ***ascending***: MEM_MDQ[31:24], MEM_DQM[***3***], and MEM_MDQS[***3***] are associated with address offset ***0*** modulo 4 (4*n*); MEM_MDQ[7:0], MEM_DQM[***0***], and MEM_MDQS[***0***] are associated with address offset ***3*** modulo 4 (4*n*+3).

## 8.3 Features

The MPC5200B SDRAM Memory Controller has the following features:

- Supports either:
  - — SDR SDRAM—memory I/Os are powered at 3.3V
  - — DDR SDRAM—memory I/Os are powered at 2.5V

  DDR SDRAM transfers data at twice the rate and uses MEM_CLK and $\overline{\text{MEM\_CLK}}$ as a differential pair.
- 32-bit memory data bus
- 16-bit memory data bus (connected only to upper half, bits 31-16, of the data bus).
- Maximum address space 512MB; 256MB per $\overline{\text{CS}}$, 32-bit memory data bus:
  - — Up to 13 bits of row address (RA[12:0])
  - — Up to 12 bits of column address (CA[11:0])
  - — 2 bits of bank address (BA[1:0])
  - — Cannot use all 13 bits of RA and all 12 bits of CA at the same time. Maximum total address bits (RA+CA+BA) ≤ 26; 26 address bits x 4Byte data bus = 256MB.

**NOTE**

In this document the Auto Precharge control signal (A10 usually), conveyed on the memory address bus along with column address, is ***never*** included in the stated CA width; it is always ***in addition*** to the CA width.

The Memory Controller does not support memory devices with >8 CA bits, but <13 RA bits.

RA[12:0] correspond directly with MEM_MA[12:0]. CA[7:0] correspond directly with MEM_MA[7:0]. CA[11:8] do ***not*** correspond directly with MEM_MA[12:8].

- Maximum address space 512MB; 256MB per $\overline{CS}$, 16-bit memory data bus:
  - — Up to 13 bits of row address (RA[12:0])
  - — Up to 13 bits of column address (CA[12:0])
  - — 2 bits of bank address (BA[1:0])

**NOTE**

In this document the Auto Precharge control signal (A10 usually), conveyed on the memory address bus along with column address, is ***never*** included in the stated CA width; it is always ***in addition*** to the CA width.

The Memory Controller does not support memory devices with >9 CA bits, but <13 RA bits.

RA[12:0] correspond directly with MEM_MA[12:0]. CA[7:0] correspond directly with MEM_MA[7:0]. CA[11:8] do ***not*** correspond directly with MEM_MA[12:8].

- Maximum of 2 pinned-out Chip Selects ($\overline{CS}$).
  - — $\overline{CS0}$ is pinned out all the time (i.e., a dedicated pin).
  - — $\overline{CS1}$ is only available if the GPIO_WKUP6 pin is programmed to be an SDRAM chip select. The default function of the pin is GPIO_WKUP6.
  - — To configure the GPIO_WKUP6 pin as SDRAM chip select, write 1 to the Port Configuration register msb.GPS Port Configuration Register

**NOTE**

The GPIO_WKUP_6 pin, which can be programmed as CS1 for the SDRAM bus, is powered by the Memory Vdd supply. When using Single Data Rate SDRAMS, the Memory Vdd supply is 3.3 volts. When using Double Data Rate SDRAMs, the Memory Vdd supply is 2.5 volts.

If GPIO_WKUP_6 is used as a GPIO pin (as opposed to CS1), the input levels must be appropriate for the voltage on the Memory Vdd supply. For instance, if DDR memory is used which requires a Vdd_mem supply of 2.5 volts, then logic levels applied to GPIO_WKUP_6 must not exceed 2.5 volts.

  - — The size of each $\overline{CS}$ space is independent. It is possible but not recommended to overlap the address space pointed to by the 2 independent chip select.

**NOTE**

Maximum 4 physical memory devices total, all $\overline{CS}$.

- Minimum allocatable address space 1MB:
  — 8 bits of row address;
  — 8 bits of column address for 32-bit interface, 9 bits of column address for 16-bit interface;
  — 2 bits of bank address;
  — 1 chip select;

**NOTE**

Minimum allocatable address space is much smaller (8Mb) than the lowest density available (64Mb). Excess memory bits are not used or simply wasted.

- 32 Byte PowerPC e300 critical word first burst transfer;
- Supports PowerPC e300 bus, 2-stage address/data pipeline (one data tenure in progress, one pipelined address tenure);
- Supports SDRAM Power Down and Self Refresh modes;
- Supports page mode and bursting to maximize the data rate;

**NOTE**

The SDRAM Memory Controller (MC) does not support error detect or parity check.

### 8.3.1 Devices Supported

Supported SDRAM devices (SDR and DDR both) are:

- 64Mbit;
- 128Mbit;
- 256Mbit;
- 512Mbit;
- 1Gbit when available, assuming the same interface style;
- 2Gbit when available, assuming the same interface style;

The MPC5200B limits external memory to a maximum of 4 memory chips placed within 5 cm of the MPC5200B processor. Flight delay on the board should be no more than 0.5 ns each way, and ***all*** signals must be matched. The maximum load is 20pF/pin.

**Table 8-1. 32-Bit External Data Width Legal Memory Configurations (Sheet 1 of 6)**

| Row Bits | Column Bits | Bank Bits | Spaces ($\overline{CS}$) | Physical | Address Range |
|---|---|---|---|---|---|
| 11 | 8 | 2 | 1 | 1 x 64Mb<br>512K x 4bank x 32bit | 8MB |
| | | | 2 | 2 x 64Mb<br>512K x 4bank x 32bit | 16MB |
| 12 | 8 | 2 | 1 | 2 x 64Mb<br>1M x 4bank x 16bit | 16MB |
| | | | | 1 x 128Mb<br>1M x 4bank x 32bit | |
| | | | 2 | 4 x 64Mb<br>1M x 4bank x 16bit | 32MB |
| | | | | 2 x 128Mb<br>1M x 4bank x 32bit | |
| 12<br>13 | 9<br>8 | 2<br>2 | 1 | 4 x 64Mb<br>2M x 4bank x 8bit | 32MB |
| | | | | 2 x 128Mb<br>2M x 4bank x 16bit | |
| | | | | 1 x 256Mb<br>2M x 4bank x 32bit | |
| | | | 2 | 4 x 128Mb<br>2M x 4bank x 16bit | 64MB |
| | | | | 2 x 256Mb<br>2M x 4bank x 32bit | |
| 12<br>13 | 10<br>9 | 2<br>2 | 1 | 4 x 128Mb<br>4M x 4bank x 8bit | 64MB |
| | | | | 2 x 256Mb<br>4M x 4bank x 16bit | |
| | | | | 1 x 512Mb<br>4M x 4bank x 32bit | |
| | | | 2 | 4 x 256Mb<br>4M x 4bank x 16bit | 128MB |
| | | | | 2 x 512Mb, 2 $\overline{CS}$<br>4M x 4bank x 32bit | |
| 12<br>13 | 11<br>10 | 2<br>2 | 1 | 4 x 256Mb<br>8M x 4bank x 8bit | 128MB |
| | | | | 2 x 512Mb<br>8M x 4bank x 16bit | |
| | | | | 1 x 1Gb<br>8M x 4bank x 32bit | |
| | | | 2 | 4 x 512Mb<br>8M x 4bank x 16bit | 256MB |
| | | | | 2 x 1Gb<br>8M x 4bank x 32bit | |

**Table 8-1. 32-Bit External Data Width Legal Memory Configurations (Sheet 2 of 6)**

| Row Bits | Column Bits | Bank Bits | Spaces ($\overline{CS}$) | Physical | Address Range |
|---|---|---|---|---|---|
| 12<br>13 | 12<br>11 | 2<br>2 | 1 | 4 x 512Mb<br>16M x 4bank x 8bit | 256MB |
| | | | | 2 x 1Gb<br>16M x 4bank x 16bit | |
| | | | | 1 x 2Gb<br>16M x 4bank x 32bit | |
| | | | 2 | 4 x 1Gb<br>16M x 4bank x 16bit | 512MB |
| | | | | 2 x 2Gb<br>16M x 4bank x 32bit | |
| 11<br><br><br>12 | 8<br><br><br>8 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 64Mb<br>512K x 4bank x 32bit<br>+<br>1 x 128Mb<br>1M x 4bank x 32bit | 24MB |
| 11<br><br><br>12<br>13 | 8<br><br><br>9<br>8 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 64Mb<br>512K x 4bank x 32bit<br>+<br>1 x 256Mb<br>2M x 4bank x 32bit | 40MB |
| 11<br><br><br>12<br>13 | 8<br><br><br>10<br>9 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 64Mb<br>512K x 4bank x 32bit<br>+<br>1 x 512Mb<br>4M x 4bank x 32bit | 72MB |
| 11<br><br><br>12<br>13 | 8<br><br><br>11<br>10 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 64Mb<br>512K x 4bank x 32bit<br>+<br>1 x 1Gb<br>8M x 4bank x 32bit | 136MB |
| 11<br><br><br>12<br>13 | 8<br><br><br>12<br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 64Mb<br>512K x 4bank x 32bit<br>+<br>1 x 2Gb<br>16M x 4bank x 32bit | 264MB |
| 12<br><br><br>12<br>13 | 8<br><br><br>9<br>8 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 64Mb<br>1M x 4bank x 16bit<br>+<br>2 x 128Mb<br>2M x 4bank x 16bit | 48MB |

**Table 8-1. 32-Bit External Data Width Legal Memory Configurations (Sheet 3 of 6)**

| Row Bits | Column Bits | Bank Bits | Spaces ($\overline{CS}$) | Physical | Address Range |
|---|---|---|---|---|---|
| 12 | 8 | 2 | 1 | 2 x 64Mb<br>1M x 4bank x 16bit | 80MB |
| | | | | + | |
| 12<br>13 | 10<br>9 | 2 | 1 | 2 x 256Mb<br>4M x 4bank x 16bit | |
| 12 | 8 | 2 | 1 | 2 x 64Mb<br>1M x 4bank x 16bit | 144MB |
| | | | | + | |
| 12<br>13 | 11<br>10 | 2 | 1 | 2 x 512Mb<br>8M x 4bank x 16bit | |
| 12 | 8 | 2 | 1 | 2 x 64Mb<br>1M x 4bank x 16bit | 272MB |
| | | | | + | |
| 12<br>13 | 12<br>11 | 2 | 1 | 2 x 1Gb<br>16M x 4bank x 16bit | |
| 12 | 8 | 2 | 1 | 1 x 128Mb<br>1M x 4bank x 32bit | 48MB |
| | | | | + | |
| 12<br>13 | 9<br>8 | 2 | 1 | 1 x 256Mb<br>2M x 4bank x 32bit | |
| 12 | 8 | 2 | 1 | 1 x 128Mb<br>1M x 4bank x 32bit | 80MB |
| | | | | + | |
| 12<br>13 | 10<br>9 | 2 | 1 | 1 x 512Mb<br>4M x 4bank x 32bit | |
| 12 | 8 | 2 | 1 | 1 x 128Mb<br>1M x 4bank x 32bit | 144MB |
| | | | | + | |
| 12<br>13 | 11<br>10 | 2 | 1 | 1 x 1Gb<br>8M x 4bank x 32bit | |
| 12 | 8 | 2 | 1 | 1 x 128Mb<br>1M x 4bank x 32bit | 272MB |
| | | | | + | |
| 12<br>13 | 12<br>11 | 2 | 1 | 1 x 2Gb<br>16M x 4bank x 32bit | |
| 12 | 9 | 2 | 1 | 2 x 128Mb<br>2M x 4bank x 16bit | 96MB |
| | | | | + | |
| 12 | 10 | 2 | 1 | 2 x 256Mb<br>4M x 4bank x 16bit | |

**Table 8-1. 32-Bit External Data Width Legal Memory Configurations (Sheet 4 of 6)**

| Row Bits | Column Bits | Bank Bits | Spaces ($\overline{CS}$) | Physical | Address Range |
|---|---|---|---|---|---|
| 13<br><br><br>13 | 8<br><br><br>9 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 128Mb<br>2M x 4bank x 16bit<br>+<br>2 x 256Mb<br>4M x 4bank x 16bit | 96MB |
| 12<br><br><br>12 | 9<br><br><br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 128Mb<br>2M x 4bank x 16bit<br>+<br>2 x 512Mb<br>8M x 4bank x 16bit | 160MB |
| 13<br><br><br>13 | 8<br><br><br>10 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 128Mb<br>2M x 4bank x 16bit<br>+<br>2 x 512Mb<br>8M x 4bank x 16bit | 160MB |
| 12<br><br><br>12 | 9<br><br><br>12 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 128Mb<br>2M x 4bank x 16bit<br>+<br>2 x 1Gb<br>16M x 4bank x 16bit | 288MB |
| 13<br><br><br>13 | 8<br><br><br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 128Mb<br>2M x 4bank x 16bit<br>+<br>2 x 1Gb<br>16M x 4bank x 16bit | 288MB |
| 12<br><br><br>12 | 9<br><br><br>10 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 256Mb<br>2M x 4bank x 32bit<br>+<br>1 x 512Mb<br>4M x 4bank x 32bit | 96MB |
| 13<br><br><br>13 | 8<br><br><br>9 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 256Mb<br>2M x 4bank x 32bit<br>+<br>1 x 512Mb<br>4M x 4bank x 32bit | 96MB |
| 12<br><br><br>12 | 9<br><br><br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 256Mb<br>2M x 4bank x 32bit<br>+<br>1 x 1Gb<br>8M x 4bank x 32bit | 160MB |

**Table 8-1. 32-Bit External Data Width Legal Memory Configurations (Sheet 5 of 6)**

| Row Bits | Column Bits | Bank Bits | Spaces ($\overline{CS}$) | Physical | Address Range |
|---|---|---|---|---|---|
| 13<br><br><br>13 | 8<br><br><br>10 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 256Mb<br>2M x 4bank x 32bit<br>+<br>1 x 1Gb<br>8M x 4bank x 32bit | 160MB |
| 12<br><br><br>12 | 9<br><br><br>12 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 256Mb<br>2M x 4bank x 32bit<br>+<br>1 x 2Gb<br>16M x 4bank x 32bit | 288MB |
| 13<br><br><br>13 | 8<br><br><br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 256Mb<br>2M x 4bank x 32bit<br>+<br>1 x 2Gb<br>16M x 4bank x 32bit | 288MB |
| 12<br><br><br>12 | 10<br><br><br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x256Mb<br>4M x 4bank x 16bit<br>+<br>2 x 512Mb<br>8M x 4bank x 16bit | 192MB |
| 13<br><br><br>13 | 9<br><br><br>10 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x256Mb<br>4M x 4bank x 16bit<br>+<br>2 x 512Mb<br>8M x 4bank x 16bit | 192MB |
| 12<br><br><br>12 | 10<br><br><br>12 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x256Mb<br>4M x 4bank x 16bit<br>+<br>2 x 1Gb<br>16M x 4bank x 16bit | 320MB |
| 13<br><br><br>13 | 9<br><br><br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x256Mb<br>4M x 4bank x 16bit<br>+<br>2 x 1Gb<br>16M x 4bank x 16bit | 320MB |
| 12<br><br><br>12 | 10<br><br><br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 512Mb<br>4M x 4bank x 32bit<br>+<br>1 x 1Gb<br>8M x 4bank x 32bit | 192MB |

**Table 8-1. 32-Bit External Data Width Legal Memory Configurations (Sheet 6 of 6)**

| Row Bits | Column Bits | Bank Bits | Spaces ($\overline{CS}$) | Physical | Address Range |
|---|---|---|---|---|---|
| 13<br><br><br>13 | 9<br><br><br>10 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 512Mb<br>4M x 4bank x 32bit<br>+<br>1 x 1Gb<br>8M x 4bank x 32bit | 192MB |
| 12<br><br><br>12 | 10<br><br><br>12 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 512Mb<br>4M x 4bank x 32bit<br>+<br>1 x 2Gb<br>16M x 4bank x 32bit | 320MB |
| 13<br><br><br>13 | 9<br><br><br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 512Mb<br>4M x 4bank x 32bit<br>+<br>1 x 2Gb<br>16M x 4bank x 32bit | 320MB |
| 12<br><br><br>12 | 10<br><br><br>12 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 512Mb<br>8M x 4bank x 32bit<br>+<br>2 x 1Gb<br>16M x 4bank x 32bit | 384MB |
| 13<br><br><br>13 | 9<br><br><br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 512Mb<br>8M x 4bank x 32bit<br>+<br>2 x 1Gb<br>16M x 4bank x 32bit | 384MB |
| 12<br><br><br>12 | 11<br><br><br>12 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 1Gb<br>8M x 4bank x 32bit<br>+<br>1 x 2Gb<br>16M x 4bank x 32bit | 384MB |
| 13<br><br><br>13 | 10<br><br><br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 1Gb<br>8M x 4bank x 32bit<br>+<br>1 x 2Gb<br>16M x 4bank x 32bit | 384MB |

**Table 8-2. 16-Bit External Data Width Legal Memory Configurations (Sheet 1 of 4)**

| Row Bits | Column Bits | Bank Bits | Spaces ($\overline{CS}$) | Physical | Address Range |
|---|---|---|---|---|---|
| 12 | 10 | 2 | 1 | 2 x 128Mb<br>4M x 4bank x 8bit | 32MB |
| | | | | 1 x 256Mb<br>4M x 4bank x 16bit | |
| | | | 2 | 4 x 64Mb<br>1M x 4bank x 16bit | 32MB |
| | | | | 2 x 128Mb<br>1M x 4bank x 32bit | |
| 12 | 9 | 2 | 1 | 2 x 64Mb<br>2M x 4bank x 8bit | 16MB |
| | | | | 1 x 128Mb<br>2M x 4bank x 16bit | |
| | | | 2 | 4 x 64Mb<br>2M x 4bank x 8bit | 32MB |
| | | | | 2 x 128Mb<br>2M x 4bank x 16bit | |
| 12 | 10 | 2 | 1 | 2 x 128Mb<br>4M x 4bank x 8bit | 32MB |
| | | | | 1 x 256Mb<br>4M x 4bank x 16bit | |
| | | | 2 | 4 x 128Mb<br>4M x 4bank x 8bit | 64MB |
| | | | | 2 x 256Mb<br>4M x 4bank x 16bit | |
| 13 | 10 | 2 | 1 | 2 x 256Mb<br>8M x 4bank x 8bit | 64MB |
| | | | | 1 x 512Mb<br>8M x 4bank x 16bit | |
| | | | 2 | 4 x 256Mb<br>8M x 4bank x 8bit | 128MB |
| | | | | 2 x 512Mb<br>8M x 4bank x 16bit | |
| 13 | 11 | 2 | 1 | 2 x 512Mb<br>16M x 4bank x 8bit | 128MB |
| | | | | 1 x 1Gb<br>16M x 4bank x 16bit | |
| | | | 2 | 4 x 512Mb<br>16M x 4bank x 8bit | 256MB |
| | | | | 2 x 1Gb<br>16M x 4bank x 16bit | |
| 12<br><br>12 | 9<br><br>9 | 2<br><br>2 | 1<br><br>1 | 2 x 64Mb<br>2Mx 4bank x 8bit<br>+<br>1 x 128Mb<br>2M x 4bank x 16bit | 32MB |

**Table 8-2. 16-Bit External Data Width Legal Memory Configurations (Sheet 2 of 4)**

| Row Bits | Column Bits | Bank Bits | Spaces ($\overline{CS}$) | Physical | Address Range |
|---|---|---|---|---|---|
| 12<br><br><br>12 | 9<br><br><br>10 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 64Mb<br>2Mx 4bank x 8bit<br>+<br>2 x 128Mb<br>4M x 4bank x 8bit | 48MB |
| 12<br><br><br>13 | 9<br><br><br>9 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 64Mb<br>2Mx 4bank x 8bit<br>+<br>1 x 256Mb<br>4M x 4bank x 16bit | 48MB |
| 12<br><br><br>13 | 9<br><br><br>10 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 64Mb<br>2Mx 4bank x 8bit<br>+<br>2 x 256Mb<br>8M x 4bank x 8bit | 80MB |
| 12<br><br><br>13 | 9<br><br><br>10 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 64Mb<br>2Mx 4bank x 8bit<br>+<br>1 x 512Mb<br>8M x 4bank x 16bit | 80MB |
| 12<br><br><br>13 | 9<br><br><br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 64Mb<br>2M x 4bank x 8bit<br>+<br>2 x 512Mb<br>16M x 4bank x 8bit | 144MB |
| 12<br><br><br>13 | 9<br><br><br>11 | 2<br><br><br>2 | 1<br><br><br>1 | 2 x 64Mb<br>2M x 4bank x 8bit<br>+<br>1 x 1Gb<br>16M x 4bank x 16bit | 144MB |
| 12<br><br><br>13 | 9<br><br><br>9 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 128Mb<br>2M x 4bank x 16bit<br>+<br>1 x 256Mb<br>4M x 4bank x 16bit | 48MB |
| 12<br><br><br>13 | 9<br><br><br>10 | 2<br><br><br>2 | 1<br><br><br>1 | 1 x 128Mb<br>2M x 4bank x 16bit<br>+<br>2 x 256Mb<br>8M x 4bank x 8bit | 80MB |

**Table 8-2. 16-Bit External Data Width Legal Memory Configurations (Sheet 3 of 4)**

| Row Bits | Column Bits | Bank Bits | Spaces ($\overline{CS}$) | Physical | Address Range |
|---|---|---|---|---|---|
| 12 | 9 | 2 | 1 | 1 x 128Mb<br>2M x 4bank x 16bit | 80MB |
| | | | | + | |
| 13 | 10 | 2 | 1 | 1 x 512Mb<br>8M x 4bank x 16bit | |
| 12 | 9 | 2 | 1 | 1 x 128Mb<br>2M x 4bank x 16bit | 144MB |
| | | | | + | |
| 13 | 11 | 2 | 1 | 2 x 512Mb<br>16M x 4bank x 8bit | |
| 12 | 9 | 2 | 1 | 1 x 128Mb<br>2M x 4bank x 16bit | 144MB |
| | | | | + | |
| 13 | 11 | 2 | 1 | 1 x 1Gb<br>16M x 4bank x 16bit | |
| 12 | 10 | 2 | 1 | 2 x 128Mb<br>4M x 4bank x 8bit | 64MB |
| | | | | + | |
| 13 | 9 | 2 | 1 | 1 x 256Mb<br>4M x 4bank x 16bit | |
| 12 | 10 | 2 | 1 | 2 x 128Mb<br>4M x 4bank x 8bit | 64MB |
| | | | | + | |
| 13 | 10 | 2 | 1 | 2 x 256Mb<br>8M x 4bank x 8bit | |
| 12 | 10 | 2 | 1 | 2 x 128Mb<br>4M x 4bank x 8bit | 80MB |
| | | | | + | |
| 13 | 10 | 2 | 1 | 1 x 512Mb<br>8M x 4bank x 16bit | |
| 12 | 10 | 2 | 1 | 2 x 128Mb<br>4M x 4bank x 8bit | 160MB |
| | | | | + | |
| 13 | 11 | 2 | 1 | 2 x 256Mb<br>16M x 4bank x 8bit | |
| 12 | 10 | 2 | 1 | 2 x 128Mb<br>4M x 4bank x 8bit | 160MB |
| | | | | + | |
| 13 | 11 | 2 | 1 | 1 x Gb<br>16M x 4bank x 16bit | |

**Table 8-2. 16-Bit External Data Width Legal Memory Configurations (Sheet 4 of 4)**

| Row Bits | Column Bits | Bank Bits | Spaces ($\overline{CS}$) | Physical | Address Range |
|---|---|---|---|---|---|
| 13 | 9 | 2 | 1 | 1 x 256Mb<br>4M x 4bank x 16bit | 96MB |
| | | | | + | |
| 13 | 10 | 2 | 1 | 1 x 512Mb<br>8M x 4bank x 16bit | |
| 13 | 9 | 2 | 1 | 1 x 256Mb<br>4M x 4bank x 16bit | 160MB |
| | | | | + | |
| 13 | 11 | 2 | 1 | 2 x 512Mb<br>16M x 4bank x 8bit | |
| 13 | 9 | 2 | 1 | 1 x 256Mb<br>4M x 4bank x 16bit | 160MB |
| | | | | + | |
| 13 | 11 | 2 | 1 | 1 x 1Gb<br>16M x 4bank x 16bit | |
| 13 | 10 | 2 | 1 | 2 x 256Mb<br>8M x 4bank x 8bit | 128MB |
| | | | | + | |
| 13 | 10 | 2 | 1 | 1 x 512Mb<br>8M x 4bank x 16bit | |
| 13 | 10 | 2 | 1 | 2 x 256Mb<br>8M x 4bank x 8bit | 192MB |
| | | | | + | |
| 13 | 11 | 2 | 1 | 2 x 512Mb<br>16M x 4bank x 8bit | |
| 13 | 10 | 2 | 1 | 2 x 256Mb<br>8M x 4bank x 8bit | 192MB |
| | | | | + | |
| 13 | 11 | 2 | 1 | 1 x 1Gb<br>16M x 4bank x 16bit | |
| 13 | 10 | 2 | 1 | 1 x 512Mb<br>8M x 4bank x 16bit | 192MB |
| | | | | + | |
| 13 | 11 | 2 | 1 | 1 x 1Gb<br>16M x 4bank x 16bit | |
| 13 | 11 | 2 | 1 | 2 x 512Mb<br>16M x 4bank x 8bit | 256MB |
| | | | | + | |
| 13 | 11 | 2 | 1 | 1 x 1Gb<br>16M x 4bank x 16bit | |

Figure 8-1 shows an example memory configuration of 1 space ($\overline{CS}$) of 4 devices of 128Mbit (4M x 4 banks x 8bit) DDR SDRAM, for a total memory size of 64MB.

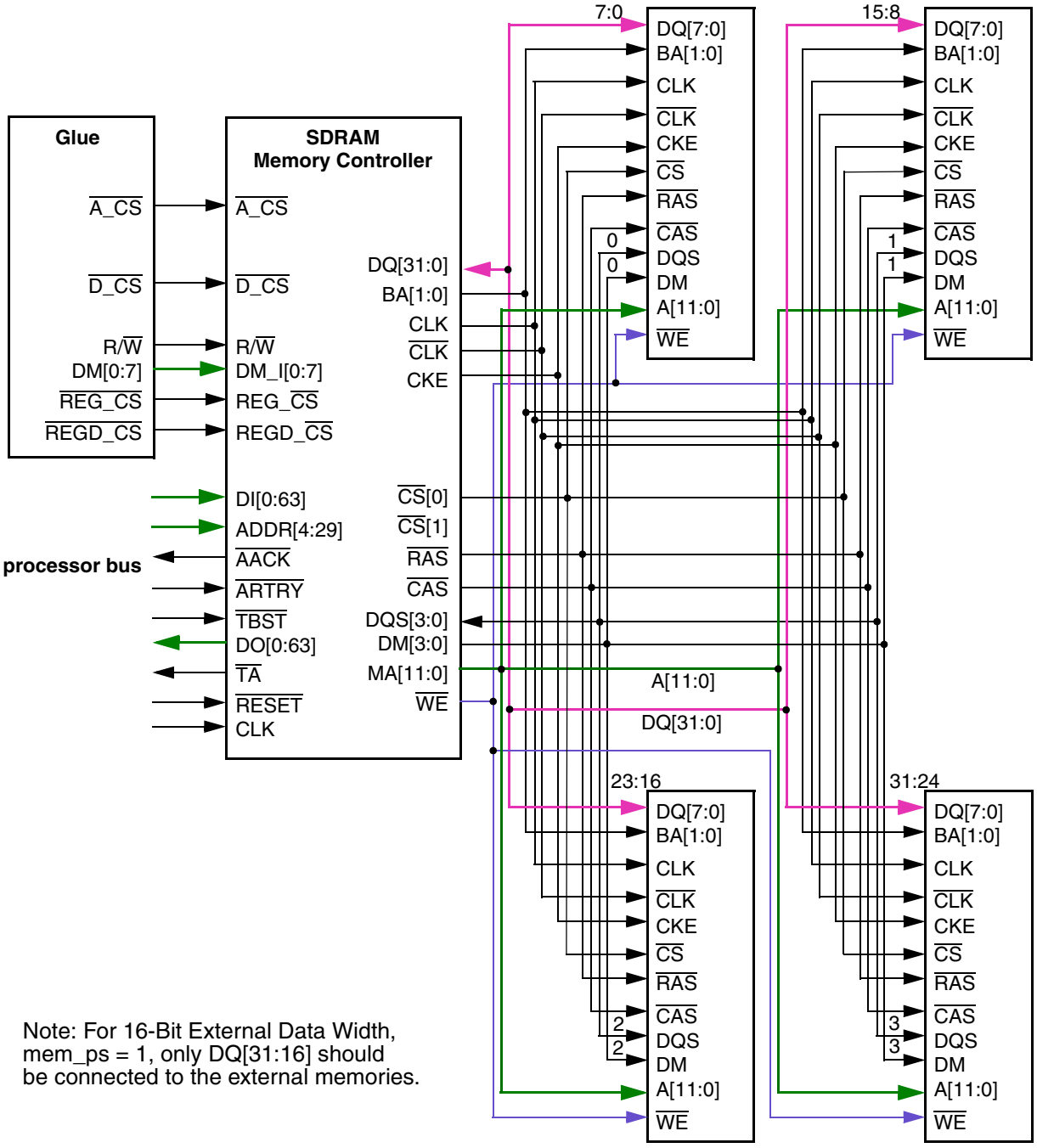



**Figure 8-1. Block Diagram—SDRAM Subsystem Example**

Both chip selects contribute together to access the whole memory. Each $\overline{CS}$ base address and size are programmed independently. Each $\overline{CS}$ base address must be size-aligned.

The MPC5200B does not support DIMM memory modules, however it can support a DIMM-compatible EEPROM using an on-chip $I^2C$ chip interface (with appropriate configuration of pin functions).

# 8.4 Functional Description

## 8.4.1 External Signals (SDRAM Side)

**Table 8-3. SDRAM External Signals**

| Signal Name | Description |
|---|---|
| Outputs | |
| MEM_CLK | Memory Clock (frequency is the same as the internal XL bus clock). Maximum allowed value is 132 MHz. |
| MEM_CLK | Inverted Memory Clock, used for DDR-SDRAM devices.<br>Internally generated “DQS” for SDR-SDRAM devices. |
| MEM_CLK_EN | Memory Clock Enable (CKE). When low, the SDRAM is disabled. Used to switch memory into and out of self-refresh/power-down modes. |
| $\overline{\text{MEM\_CS}}$[0],<br>$\overline{\text{MEM\_CS}}$[1] | Memory Command Select. Each space has a command select to enable commands |
| MEM_RAS | Memory Row Address Select |
| MEM_CAS | Memory Column Address Select |
| MEM_WE | Memory Write Enable |
| MEM_MA[12:0] | Memory Multiplexed Address. These are used as row address, column address, or Mode(Extended Mode) register data, depending on the command issued.<br>Row address during Active command.<br>Column address during Read and Write commands. MEM_MA10 is used as a control signal instead of an address line, to control Auto Precharge operation. The Auto Precharge control bit is not counted as a column address bit. The Memory Controller does not use Auto Precharge.<br>Mode register data during Load Mode Register and Load Extended Mode Register (DDR only) commands. |
| MEM_MBA[1:0] | Memory Bank Address, or Mode register select, depending on the command issued.<br>Bank address during Precharge Selected, Active, Read, and Write commands. The Memory Controller does not use the Precharge Selected command.<br>Mode register select during Load Mode Register and Load Extended Mode Register (DDR only) commands. Although SDR memory only has a single internal Mode register, the Bank Address bits must still be valid. |
| MEM_DQM[3:0] | Memory Data Mask. Addressing = 0:3<br>0 Data byte read/write is enabled<br>1 Data byte read/write is inhibited<br>SDR memories 3-state inhibited data during reads; DDR memories ignore Data Mask during reads. The memory controller never masks read data. |
| Bidirectional Signals | |
| MEM_MDQ[31:0] | Memory Data. Addressing = 0:3. |
| MEM_MDQS[3:0] | Memory Data Strobe, DDR only. Addressing = 0:3. |

**Note:** Signals $\overline{\text{MEM\_RAS}}$, $\overline{\text{MEM\_CAS}}$, $\overline{\text{MEM\_WE}}$, and MEM_CLK_EN encode the SDRAM commands to control the different SDRAM operations.

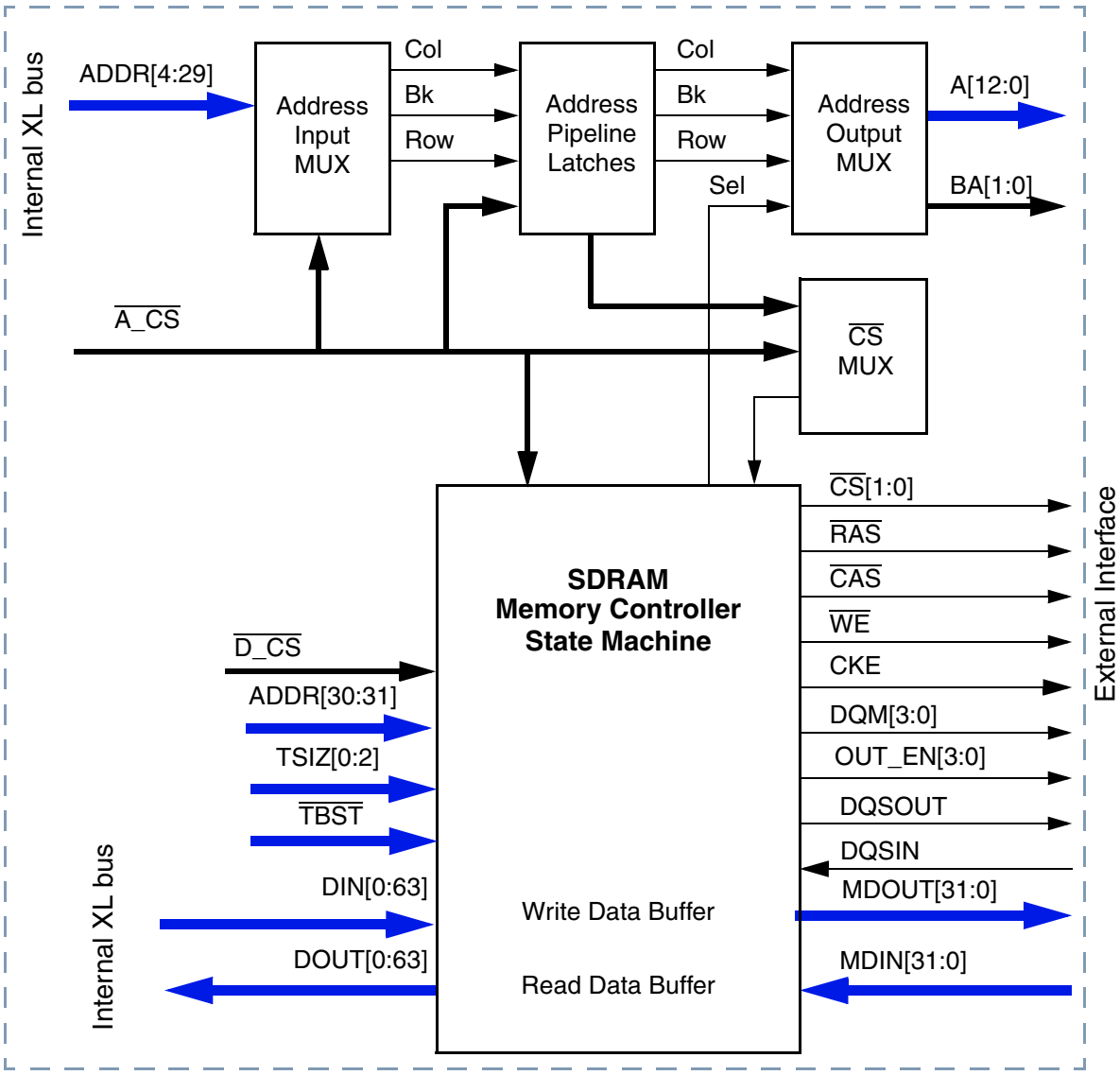
**Note:** For 16-bit mode external pull-down devices are required on MEM_MDQS[1:0].

## 8.4.2 Block Diagram

Figure 8-2 shows the SDRAM MC block diagram. It is important to notice:

- the internal XL bus is 64 bits wide
- the external interface to the SDRAM is only 32 bits wide

The SDRAM row, column, and bank address bits are extracted from internal address XLA[4:29]; XLA[29:31], TSIZ[0:2], and $\overline{\text{TBST}}$ control the data path (MDQ, DQM).




Note: For 16-Bit External Data Width, mem_ps = 1, only MDOUT[31:16] and MDIN[31:16] should be connected to the external memories.

**Figure 8-2. Block Diagram—SDRAM Memory Controller**

### 8.4.3 Transfer Size

All SDRAMs are “burst oriented” for read and write operations. The memory will move a full burst of data for every Read and Write command unless the command is interrupted by a new command, explicitly terminated, or the data is masked. (Data mask does not shorten the command, it only inhibits data capture.) The Memory Controller can interrupt certain commands, by supporting the explicit Burst Terminate command.

The Memory Controller supports Burst and Non-Burst, or Single, transfers corresponding to the homonymous XL bus transfer types. A Burst transfer is a 32 Byte block, 4 XLB data beats (8 memory data beats), spanning a modulo 32 address range. The starting address can be any modulo 8 boundary within the modulo 32 range; the address “wraps” from the highest address to the lowest address of the range if the starting address is not aligned at the beginning of the range. No data is masked during a burst.

The beat address order of the XL bus is ***sequential***. Based on the start address issued by the internal master, the address order of the 4 XLD beats in a burst transfer is one of the following:

- 0x00, 0x08, 0x10, 0x18 (memory data address order 0x00, 0x04, 0x08, 0x0c, ...)
- 0x08, 0x10, 0x18, 0x00
- 0x10, 0x18, 0x00, 0x08
- 0x18, 0x00, 0x08, 0x10

To implement single-beat transfers, the Memory Controller uses DM[3:0] to mask unwanted bytes or words. The Memory Controller supports all single-beat transfer sizes from 1 to 8 contiguous bytes within a single modulo 8 address range.

A Single transfer is exactly 1 beat on the XLD bus. The relevant data for a Single transfer is always within the first 2 beats on the memory bus, allowing the command to be aborted (interrupt) as soon as possible.

### 8.4.4 Commands

When an internal bus master accesses SDRAM address space, the Memory Controller generates the corresponding SDRAM command. Table 8-4 lists SDRAM commands supported by the Memory Controller.

**Table 8-4. SDRAM Commands**

| Function | Symbol | CKE | CS | RAS | CAS | WE | BA[1:0] | A10 | Other A |
|---|---|---|---|---|---|---|---|---|---|
| Command Inhibit | INH | H | H | X | X | X | X | X | X |
| No Operation | NOP | H | L | H | H | H | X | X | X |
| Read | READ | H | L | H | L | H | V | L | V |
| Write | WRIT | H | L | H | L | L | V | L | V |
| Row and Bank Active | ACT | H | L | L | H | H | V | V | V |
| Burst Terminate | BST | H | L | H | H | L | X | X | X |
| Precharge All Banks | PALL | H | L | L | H | L | X | H | X |
| Load Mode Register | LMR | H | L | L | L | L | LL | V | V |

**Table 8-4. SDRAM Commands (continued)**

| Function | Symbol | CKE | CS | RAS | CAS | WE | BA[1:0] | A10 | Other A |
|---|---|---|---|---|---|---|---|---|---|
| Load Extended Mode Register | LEMR | H | L | L | L | L | LH | V | V |
| CBR Auto Refresh | AREF | H | L | L | L | H | X | X | X |
| Self Refresh | SREF | H→L | L | L | L | H | X | X | X |
| Power Down | PDWN | H→L | H | X | X | X | X | X | X |

**Note:**

1. H = High
2. L = Low
3. V = Valid
4. X = Don't care

Many commands require a delay before the next command may be issued; sometimes the delay depends on the type of the next command. These delay requirements are managed by the values programmed in the Memory Controller Configuration registers.

### 8.4.4.1 Load Mode/Extended Mode Register Command

The Load Mode Register (LMR) and Load Extended Mode Register (LEMR) commands are used during SDRAM initialization only.

When a bus master writes to the Memory Controller Mode register, the Memory Controller generates the LMR or LEMR command to forward the data to the memory. In these two operations, data written to the Memory Controller is put on the SDRAM address and bank select busses. The bank select data selects the Mode or Extended Mode register.

The Memory Controller Mode register must be enabled before writing, and disabled after all memory Mode register operations are complete. This is done by setting or clearing the Control register mode_en bit. See Section 8.6.1.1, "Memory Controller Mode Register."

Some of the configuration parameters required by the memory are also needed by the Memory Controller for command generation. The parameters are:

- burst length
- latency

These must be programmed in the Memory Controller Configuration registers separately from setting the memory Mode register.

### 8.4.4.2 Precharge All Banks Command

The Memory Controller issues the Precharge command only when necessary for one of the following conditions:

- Access to a new row
- Refresh interval elapsed
- Software commanded Precharge

**NOTE**

DRAMs also have a maximum bank open period, after which a precharge is required. The Memory Controller does not time the bank open period because the refresh interval is always less.

The Precharge command puts SDRAM into an idle state. In this state, the following commands can be issued:

- Refresh
- Bank Active
- Load Mode/Extended Mode Register

**NOTE**

The Memory Controller does not support the Precharge Selected Bank memory command.

### 8.4.4.3 Row and Bank Active Command

SDRAM devices have 4 internal banks. A particular row and bank of memory must be activated to allow read and write accesses. For page mode support, the Memory Controller keeps the active row and bank(s) open as long as possible.

In an SDRAM device each internal bank can have one active row. The Bank Active command activates a row of one bank. The Memory Controller only supports the same active row in all banks of each $\overline{CS}$ space independently. The page size of a $\overline{CS}$ space is equal to the space size divided by the number of rows; but the page may not be contiguous in the XLB address space because the XLA bits for memory column address bits [11:8] and memory column address [7:0] are not consecutive. The size of a contiguous page segment is 4KB, corresponding to 8 CA bits plus 2 BA bits times 4Bytes of data.

Each $\overline{CS}$ space almost always has an active row. If no row is already active, any read or write access will activate one; and the only reasons that a row is deactivated are to activate a different one instead, or to perform a refresh.

#### 8.4.4.4 Read Command

When the Memory Controller receives a read request via the XL bus, it first checks the row and bank of the new access. If the address falls within the active row of an active bank, it is a page hit, and the Read command is issued as soon as possible (pending any delays required by previous commands). If the address is within the active row, but the needed bank is inactive, or if there is no active row, the Memory Controller will issue a Bank Active command followed by the Read command. If the address is not within the active row, the Memory Controller will issue a Precharge command to close the active row, followed by a Bank Active command to activate the necessary bank and row for the new access, followed finally by the Read command.

The Precharge and Bank Active commands (if necessary) can sometimes be issued in parallel with an on-going data movement.

All Reads, whether Burst or Single, must be allowed to complete the entire burst length on the memory bus. With SDR memory, the Data Masks are negated throughout the entire Read burst length. With DDR memory, the Data Masks are ***asserted*** throughout the entire Read burst length; but DDR memory ignores the Data Masks during Reads.

#### 8.4.4.5 Write Command

When the Memory Controller receives a write request via the XL bus, it first checks the row and bank of the new access. If the address falls within the active row of an active bank, it is a page hit, and the Write command is issued as soon as possible (pending any delays required by previous commands). If the address is within the active row but the needed bank is inactive, or if there is no active row, the Memory Controller will issue a Bank Active command followed by the Write command. If the address is not within the active row, the Memory Controller will issue a Precharge command to close the active row, followed by a Bank Active command to activate the necessary row and bank for the new access, followed finally by the Write command.

The Precharge and Bank Active commands (if necessary) can sometimes be issued in parallel with an on-going data movement.

With both SDR and DDR memory, a Read command can be issued overlapping the masked beats at the end of a previous Single Write of the same $\overline{CS}$; the Read command aborts the remaining (unnecessary) Write beats. With DDR memory, a Read of one $\overline{CS}$ can even overlap the masked beats at the end of a previous Single Write of the other $\overline{CS}$. The Write is not aborted, but the masks remain asserted. This is not possible with SDR memory, because SDR memory cannot be read with the masks asserted.

#### 8.4.4.6 Burst Terminate Command

SDRAMs are burst-only devices, but they provide mechanisms to truncate a burst if not all of the beats are needed. The burst terminate command is used to truncate read bursts (SDR and DDR) and write bursts (SDR). The most recently registered read or write command prior to the burst terminate command will be truncated. The open page which the read or write burst was terminated from remains open.

### 8.4.4.7 Auto Refresh Command

The Memory Controller issues Auto Refresh commands according to the ref_interval value specified in the Memory Controller Control register. Each time the programmed refresh interval elapses, the Memory Controller issues a Precharge All Banks command followed by an Auto Refresh command.

If a memory access is in progress at the time the refresh interval elapses, the Memory Controller schedules the refresh after the transfer is finished; but the interval timer continues counting so that the average refresh rate is constant.

After refresh, the SDRAM is in an idle state and waits for an Active command.

### 8.4.4.8 Self Refresh and Power Down Commands

The Memory Controller issues either a Power Down or a Self Refresh command if the Control register cke bit is changed from asserted to negated. If the ref_en bit of the same register is asserted when cke is negated, the controller issues a Self Refresh command; if the ref_en bit is negated, the controller issues a Power Down command. The ref_en bit may be changed in the same register write that changes the cke bit; the controller will act upon the new value of the ref_en bit.

Unlike an Auto Refresh, the controller does ***not*** automatically issue a Precharge command before the Self Refresh command. It is a software responsibility to command a Precharge, using the Control register soft_pre bit, by a separate write before negating the cke bit.

The memory is reactivated from Power Down or Self Refresh mode by reasserting the cke bit.

If a normal refresh interval elapses while the memory is in Self Refresh mode, a Precharge and Auto Refresh will be performed as soon as the memory is reactivated. If the memory is put into and brought out of Self Refresh all within a single refresh interval, the next automatic refresh will occur on schedule.

In Self Refresh mode, the memory does not require an external clock. The MEM_CLK can be stopped for maximum power savings by negating the Memory Controller Clock Enable bit of the CDM Clock Enable register. See Section 5.5.1.6, “CDM Clock Enable Register.” If the Memory Controller clock is stopped, the refresh interval timer must be reset before the memory is reactivated (if periodic refresh is to be resumed). The refresh interval timer is reset by negating the Control register ref_en bit. This can be done at any time while the memory is in Self Refresh mode, before or after the Memory Controller clock is stopped/restarted, but ***not*** with the same Control register write that negates cke; this would put the memory in Power Down mode. To restart periodic refresh when the memory is reactivated, the ref_en bit must be reasserted; this can be done before the memory is reactivated, or in the same Control register write that cke is reasserted.

**NOTE**

As soon as the CKE signal is negated (set to a logical 0) a SDRAM memory device does ***NOT*** answer any longer to any command (all its input but the CKE are ignored) until the CKE is re-asserted and a minimum time has elapsed (as specified by the memory vendor).

# 8.5 Operation

## 8.5.1 Power-Up Initialization

The SDRAM and SDRAM MC must be initialized after power-up. SDRAM parameters may be read from an $I^2C$ serial EEPROM, or compiled into the boot ROM. See Section 18.1, Overview if using serial EEPROM.

The steps below should be followed to initialize the memory system.

**NOTE**

The sequence might change slightly from device to device. Refer to the device data sheet for the most up-to-date information. In any case of conflict between this document and the device data sheet, the data sheet shall prevail.

Step 1. After reset is deactivated, pause for the amount of time indicated in the SDRAM specification. Usually 100 µs or 200 µs.

Step 2. Determine the number of SDRAM $\overline{CS}$ spaces. If using both $\overline{CS}$ spaces, configure GPIO_WKUP6/$\overline{CS1}$ for $\overline{CS1}$ mode.

If all the memory and controller register values have been precalculated and stored in ROM, skip step 3 and go directly to step 4. Otherwise, continue with step 3.

Step 3. Read the SDRAM parameters (type, size, address muxing, timing), and determine the memory clock frequency. (The memory clock frequency is always equal to the XLB frequency.) Using the SDRAM parameters and the clock frequency, calculate all the memory and controller register values now. Certain register fields are mandatory:

- Memory Mode register Burst Mode = Sequential
- Memory Mode register Burst Length = 8
- Controller Configuration register 2 burst_length = 7
- Controller Control register cke = 1

Do not write any registers yet. Use these register values as default values for the following operations. An operation can override the default, but overrides do not carry forward to subsequent operations.

Step 4. Write the SDRAMCS Configuration registers and the controller Config registers 1 & 2.

Step 5. Write the controller Control register with these overrides:

- assert the mode_en bit (1).
- negate ref_en (0).

Step 6. (DDR only) Write the controller Control register to issue a Precharge All Banks command (soft_pre=1); maintain mode_en=1, ref_en=0, all other bits default.

Step 7. (DDR only) Write to the memory Extended Mode register to enable the DLL.

Step 8. (DDR only) Write to the memory Mode register to reset the DLL.

Step 9. (DDR only) Pause for the DLL lock time specified by the memory (roughly 100 µs. See memory data sheet for detailed time).

Step 10. Write to the controller Control register to issue a Precharge All Banks command (soft_pre=1); maintain mode_en=1, ref_en=0.

Step 11. Write to the controller Control register to issue 2 or more Auto Refresh commands (soft_ref=1); maintain mode_en=1, ref_en=0. Each command requires a separate write.

Step 12. Write to the memory Mode register to specify normal operation.

Step 13. Write to the controller Control register to specify normal operation.

### 8.5.2 Read Clock

The MPC5200B implements a self-calibrating, software adjustable, read clock recovery circuit. A 400 tap master delay chain, continuously measures either the half or full period delay of the memory clock. The master tap value is used to derive a 1/4 period tap value, for use in 4 independent, 256 tap, slave delay chains. In DDR mode, the MDQS signal is used to generate the 1/4 period delayed read clock. In SDR mode, an internally generated “DQS” signal is used to generate the 1/4 period delayed read clock. For both DDR and SDR memories, the delayed read clock is used to latch the data from the memories.

## 8.6 Programming the SDRAM Controller

The Memory Controller registers consist of:

- Memory Controller Mode Register / SDRAM MC Extended Mode Register (MBAR+0x0100), write only
- Memory Controller Control Register (MBAR+0x0104)
- Memory Controller Configuration Register 1 (MBAR+0x0108)
- Memory Controller Configuration Register 2 (MBAR+0x010C)

All registers are 32bit-aligned in memory (modulo 4 address boundary).

## 8.6.1 Memory Controller Registers

### 8.6.1.1 Memory Controller Mode Register

Each time the 32-bit write-only mode register (mode[0:31]) is written (and cmd is set to 1), the controller generates a Load Mode Register or Load Extended Mode Register command to memory.

The memory Mode/Extended Mode registers must be initialized during the system boot sequence; but before writing to the controller Mode register, the mode_en and cke bits in the Control register must be set to 1. After memory initialization is complete, the Control register mode_en bit should be cleared to prevent subsequent access to the controller Mode register.

Address MBAR + 0x0100

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | | | | | | | | | | | | | | | Rsvd | |
| W | MEM_MBA [1:0] | | MEM_MA[11:0] | | | | | | | | | | | | | cmd |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 8-3. Memory Controller Mode Register**

**Table 8-5. Memory Controller Mode Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | MEM_MBA [1:0] | See SDRAM data sheet. Select either the memory device Mode register or the memory device Extended Mode register, if present. |
| 2:13 | MEM_MA[11:0] | See SDRAM data sheet. MPC5200B supports:<br>Read CAS Latency, SDR: 2, 3<br>Read CAS Latency, DDR: 2, 2.5<br>Burst type: Sequential only<br>Burst length: 8 only<br>Other fields: As appropriate<br>Specific bit allocation can vary from device to device. All devices in all $\overline{CS}$ spaces must have compatible format(s), because all are written at the same time with the same value. |
| 14 | — | Reserved |
| 15 | cmd | 1 Generate a (Extended) Mode Register Set memory command. Applied to all $\overline{CS}$ at once.<br>0 Do not generate any memory command. |
| 16:31 | — | Reserved |

### 8.6.1.2 Memory Controller Control Register

The 32-bit read/write Control register controls specific operations and generates some SDRAM commands. This register is reset only by a power-up reset signal.

Address MBAR + 0x0104

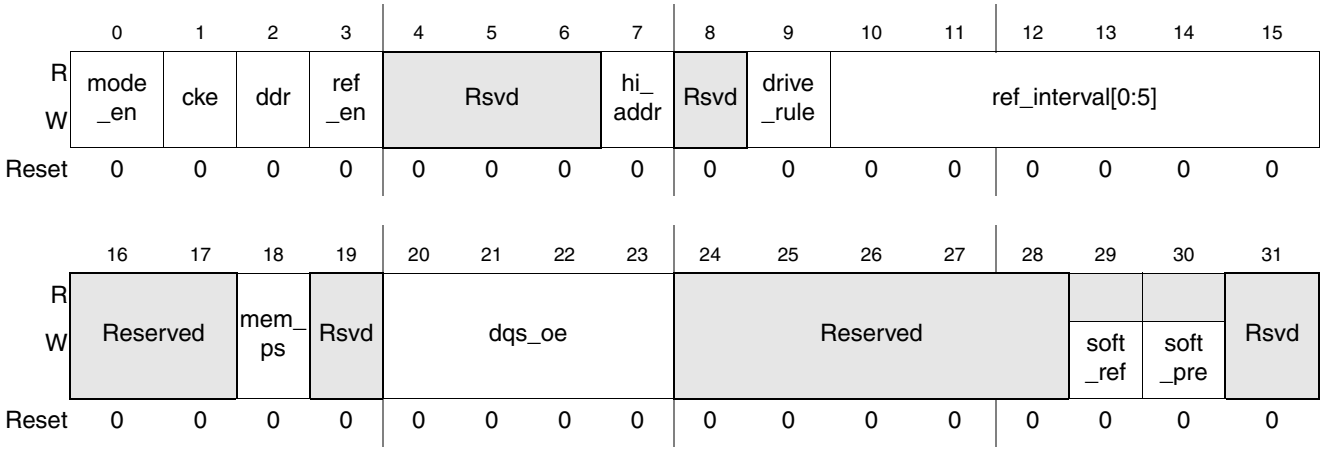



**Figure 8-4. Memory Controller Mode Register**

**Table 8-6. Memory Controller Control Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | mode_en | 0 Mode register locked, cannot be written.<br>1 Mode register enabled, can be written. |
| 1 | cke | 0 MEM_CLK_EN negated (low).<br>1 MEM_CLK_EN asserted (high).<br>cke must be set to 1 to perform normal read and write operations. Set cke to 0 to put the memory in Self Refresh or Power Down mode. |
| 2 | ddr | 0 SDR mode.<br>1 DDR mode. |
| 3 | ref_en | 0 Automatic refresh disabled.<br>1 Automatic refresh enabled.<br>In general, refresh must be enabled, unless the system is known to access memory in a pattern that is guaranteed to open every row in every bank within every refresh period $t_{REF}$. Some memory data sheets do not spec $t_{REF}$, but spec $t_{REFI}$ instead. In this case, $t_{REF} = t_{REFI}$ x #rows.<br>NOTE: The number of Refresh commands required in $t_{REF}$ is #rows; if refresh is disabled, the number of Read/Write commands required in $t_{REF}$ is #rows x 4banks. |
| 4:6 | — | Reserved |
| 7 | hi_addr | Control the use of internal address bits XLA[4:7] as row or column bits on the MEM_MA bus. See Table 8-7. |
| 8 | — | Reserved (must be written 0) |
| 9 | drive_rule | 0 “Tri-state except to write” mode: MPC5200B drives the MDQ and MDQS lines only when necessary to perform write commands.<br>1 “Drive except to read” mode: MPC5200B tri-states the MDQ and MDQS lines only when necessary to perform read commands.<br>“Drive except to read” mode prevents unterminated memory signals from floating for extended periods. However, terminated routing is always recommended over unterminated. |

**Table 8-6. Memory Controller Control Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 10:15 | ref_interval[0:5] | The average periodic interval at which the controller generates refresh commands to memory; measured in increments of 64 x MEM_CLK period.<br>1) Multiply $t_{REFI}$ by the MEM_CLK frequency. (If the memory data sheet does not define $t_{REFI}$, it can be calculated by $t_{REFI} = t_{REF} / \#rows$.)<br>Example: Assume $t_{REF}$ = 64ms, #rows = 4K, MEM_CLK = 133MHz. Then:<br>$t_{REFI}$ = 64ms / 4K = 15.625µs; 15.625µs x 133MHz = 2078.1<br>2) Divide the previous result by 64, rounding toward 0<br>2078.1 / 64 = 32.471; discard the fractional part.<br>3) Subtract 1 from the previous result. The new result is ref_interval.<br>32 - 1 = 31 = 0x1f |
| 16:17 | — | Reserved |
| 18 | mem_ps | Memory data port size.<br>0 32-bit data bus.<br>1 16-bit data bus (upper two data bytes, MEM_MDQ[31:16]). |
| 19 | — | Reserved |
| 20:23 | dqs_oe[3:0] | Each bit individually controls one MEM_MDQS output.<br>0 The corresponding MEM_MDQS pin is ***never*** driven, regardless of memory operation and drive_rule. Always set to 0000 for SDR.<br>1 The corresponding MEM_MDQS pin ***can*** be driven, depending on memory operations and drive_rule. DDR only. |
| 24:28 | — | Reserved |
| 29 | soft_ref | 0 No operation.<br>1 Generate a non-periodic Auto Refresh command as soon as possible.<br>This is a write-only bit; always returns 0 on a read. A software requested refresh is completely independent of the periodic refresh interval counter. Software refresh is only possible when mode_en==1. |
| 30 | soft_pre | 0 No operation.<br>1 Generate a Precharge All command as soon as possible.<br>This is a write-only bit; always returns 0 on a read. Software precharge is only possible when mode_en==1. |
| 31 | — | Reserved |

The Table 8-7 indicates how the internal address bits XLA[4:7] are multiplexed internally to support higher column or row address bits.

**Table 8-7. High Address Usage**

| hi_addr | XL Bus Address Line Mapping to Column or Row Address | | | |
|---|---|---|---|---|
| | 4 | 5 | 6 | 7 |
| 32-Bit Data Bus | | | | |
| 0 | CA12 | CA11 | CA9 | CA8 |
| 1 | CA11 | CA9 | CA8 | RA12 |
| 16-Bit Data Bus | | | | |
| 0 | CA13 | CA12 | CA11 | CA9 |
| 1 | CA12 | CA11 | CA9 | RA8 |

**Table 8-8. 32-Bit SDRAM Address Multiplexing**

| Device | Structure | Row bits × Col bits × Bank bits | hi_ addr | Internal XLA[4:29] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 4 | 5 | 6 | 7 | 8 | 9:19 | 20:21 | 22:29 |
| 64Mbit | 2Mx32bit | 11x8x2 | 0 | —[1] | — | — | — | — | RA [10:0] | BA [1:0] | CA [7:0] |
| | 4M×16bit | 12×8×2 | 0 | — | — | — | — | RA[11:0] | | | |
| | 8M×8bit | 12×9×2 | 0 | — | — | — | CA8 | | | | |
| | | 13×8×2 | 1 | — | — | — | RA12 | | | | |
| 128Mbit | 4M×32bit | 12×8×2 | 0 | — | — | — | — | RA[11:0] | | BA [1:0] | CA [7:0] |
| | 8M×16bit | 12×9×2 | 0 | — | — | — | CA8 | | | | |
| | | 13×8×2 | 1 | — | — | — | RA12 | | | | |
| | 16M×8bit | 12×10×2 | 0 | — | — | CA9 | CA8 | | | | |
| | | 13×9×2 | 1 | — | — | CA8 | RA12 | | | | |
| 256Mbit | 8M×32bit | 12×9×2 | 0 | — | — | — | CA8 | RA[11:0] | | BA [1:0] | CA [7:0] |
| | | 13×8×2 | 1 | — | — | — | RA12 | | | | |
| | 16M×16bit | 12×10×2 | 0 | — | — | CA9 | CA8 | | | | |
| | | 13×9×2 | 1 | — | — | CA8 | RA12 | | | | |
| | 32M×8bit | 12×11×2 | 0 | — | CA11 | CA9 | CA8 | | | | |
| | | 13×10×2 | 1 | — | CA9 | CA8 | RA12 | | | | |
| 512Mbit | 16M×32bit | 12×10×2 | 0 | — | — | CA9 | CA8 | RA[11:0] | | BA [1:0] | CA [7:0] |
| | | 13×9×2 | 1 | — | — | CA8 | RA12 | | | | |
| | 32M×16bit | 12×11×2 | 0 | — | CA11 | CA9 | CA8 | | | | |
| | | 13×10×2 | 1 | — | CA9 | CA8 | RA12 | | | | |
| | 64M×8bit | 12×12×2 | 0 | CA12 | CA11 | CA9 | CA8 | | | | |
| | | 13×11×2 | 1 | CA11 | CA9 | CA8 | RA12 | | | | |
| 1Gbit | 32Mx32bit | 12×11×2 | 0 | — | CA11 | CA9 | CA8 | RA[11:0] | | BA [1:0] | CA [7:0] |
| | | 13×10×2 | 1 | — | CA9 | CA8 | RA12 | | | | |
| | 64Mx16bit | 12×12×2 | 0 | CA12 | CA11 | CA9 | CA8 | | | | |
| | | 13×11×2 | 1 | CA11 | CA9 | CA8 | RA12 | | | | |
| 2Gbit | 64Mx32bit | 12×12×2 | 0 | CA12 | CA11 | CA9 | CA8 | RA[11:0] | | BA [1:0] | CA [7:0] |
| | | 13×11×2 | 1 | CA11 | CA9 | CA8 | RA12 | | | | |

[1] All MEM_MA pins are driven in all cases, but only the bits used by memory are listed.

**Table 8-9. 16-Bit SDRAM Address Multiplexing**

| Device | Structure | Row bits × Col bits × Bank bits | hi_ addr | Internal XLA[4:30] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 4 | 5 | 6 | 7 | 8 | 9:19 | 20:21 | 22:30 |
| 64Mbit | 8Mx8bit | 12x9x2 | 0 | —[1] | — | — | — | RA[11:0] | | BA [1:0] | CA [8:0] |
| 128Mbit | 8Mx16bit | 12x9x2 | 0 | — | — | — | — | RA[11:0] | | BA [1:0] | CA [8:0] |
| | 16Mx8bit | 12x10x2 | 0 | — | — | — | CA9 | | | | |
| | | 13x9x2 | 1 | — | — | — | RA12 | | | | |
| 256Mbit | 8Mx32bit | 12x9x2 | 0 | — | — | — | — | RA[11:0] | | BA [1:0] | CA [8:0] |
| | 16Mx16bit | 12x10x2 | 0 | — | — | — | CA9 | | | | |
| | | 13x9x2 | 1 | — | — | — | RA12 | | | | |
| | 32Mx8bit | 12x11x2 | 0 | — | — | CA11 | CA9 | | | | |
| | | 13x10x2 | 1 | — | — | CA9 | RA12 | | | | |
| 512Mbit | 16Mx32bit | 12x10x2 | 0 | — | — | — | CA9 | RA[11:0] | | BA [1:0] | CA [8:0] |
| | | 13x9x2 | 1 | — | — | — | RA12 | | | | |
| | 32Mx16bit | 12x11x2 | 0 | — | — | CA11 | CA9 | | | | |
| | | 13x10x2 | 1 | — | — | CA9 | RA12 | | | | |
| | 64Mx8bit | 12x12x2 | 0 | — | CA12 | CA11 | CA9 | | | | |
| | | 13x11x2 | 1 | — | CA11 | CA9 | RA12 | | | | |
| 1Gbit | 32Mx32bit | 12x11x2 | 0 | — | — | CA11 | CA9 | RA[11:0] | | BA [1:0] | CA [8:0] |
| | | 13x10x2 | 1 | — | — | CA9 | RA12 | | | | |
| | 64Mx16bit | 12x12x2 | 0 | — | CA12 | CA11 | CA9 | | | | |
| | | 13x11x2 | 1 | — | CA11 | CA9 | RA12 | | | | |
| 2Gbit | 64Mx32bit | 12x12x2 | 0 | — | CA12 | CA11 | CA9 | RA[11:0] | | BA [1:0] | CA [8:0] |
| | | 13x11x2 | 1 | — | CA11 | CA9 | RA12 | | | | |

[1] All MEM_MA pins are driven in all cases, but only the bits used by memory are listed.

### 8.6.1.3 Memory Controller Configuration Register 1

The 32-bit read/write Configuration register 1 stores delay values necessary between specific SDRAM commands. During initialization, software loads values to the register according to the SDRAM information obtained from the data sheet. This register is reset only by a power-up reset signal.

The Read and Write Latency fields govern the relative timing of commands and data, and must be exact values. All other fields govern the relative timing from one command to another, they have minimum values but any larger value is also legal (but with decreased performance). The “suggested values” are based on the maximum routing delay of memory signals and the MPC5200B maximum memory frequency

of 133MHz; they do not guarantee maximum performance for actual board routing delay or operating frequency.

The minimum values of certain fields can be different for SDR and DDR SDRAM, even if the data sheet timing is the same, because:

- In SDR mode, the Memory Controller counts the delay in MEM_CLK
- In DDR mode, the Memory Controller counts the delay in 2xMEM_CLK (also referred to as MEM_CLK2)

MEM_CLK—Memory Controller clock—is the speed of the SDRAM interface and is equal to the internal XL bus clock. MEM_CLK is fixed at boot time along with the XL bus clock, via the HW RESET WORD setting. It is an integer multiple of the external reference clock (e.g., 66MHz, 99MHz or 132MHz if a 33MHz reference is used).

MEM_CLK2—double frequency of MEM_CLK—DDR uses both edges of the bus-frequency clock (MEM_CLK) to read/write data.

Address MBAR + 0x0108

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | srd2rwp | | | | swt2rwp | | | | rd_latency | | | | Rsvd | act2rw | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Rsvd | pre2act | | | ref2act | | | | Rsvd | wr_latency | | | Reserved | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 8-5. Memory Controller Configuration Register 1**

**Table 8-10. Memory Controller Configuration Register 1 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | srd2rwp | Single Read to Read/Write/Precharge delay. Limiting case is Read to Write:<br>For DDR: CL + round trip delay + $t_{Hz}$; round up.<br>If round trip delay = 1 clk and $t_{Hz}$ = 0.75 ns::<br>If CL==2: 2 + 1 + 0.75 ns = 3 clk + 0.75 ns, round to 0x3.<br>If CL==2.5: 2.5 + 1 + 0.75 ns = 3.5 clk + 0.75ns, round to 0x4<br><br>For SDR: CL + round trip delay + $t_{Hz}$ + 1; round up.<br>If round trip delay = 1 clk and $t_{Hz}$ = 5.4 ns:<br>If CL==2: 2 + 1 + 5.4ns + 1 = 4 clk + 5.4ns, round to 0x5.<br>If CL==3: 3 + 1 + 5.4ns + 1 = 5 clk + 5.4ns, round to 0x6. |
| 4 | — | Reserved |
| 4:7 | swt2rwp | Single Write to Read/Write/Precharge delay. Limiting case is Write to Precharge.<br>For DDR, suggested value = 0x3 ($t_{WR}$ + 1 clk)<br>For SDR, suggested value = 0x2 ($t_{WR}$) |

**Table 8-10. Memory Controller Configuration Register 1 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 8:11 | rd_latency | Read CAS Latency.<br>For DDR:<br>If CL==2, write 0x6<br>If CL==2.5, write 0x7<br>For SDR:<br>If CL==2, write 0x2<br>If CL==3, write 0x3<br>**Note:** NOTE: CL=2.5 is not supported for SDR. |
| 12 | — | Reserved |
| 13:15 | act2rw | Active to Read/Write delay.<br>Suggested value at 132 MHz = 0x02<br>Rule: $t_{RCD}$/MEM_CLK-1. Round up to nearest integer.<br>EXAMPLE:<br>If $t_{RCD}$ = 20ns and MEM_CLK = 99 MHz<br>20ns / 10.1 ns = 1.98; round to 2; write 0x1.<br>If $t_{RCD}$ = 20 ns and MEM_CLK = 132 MHz<br>20ns / 7.5 ns = 2.66; round to 3; write 0x2. |
| 16 | — | Reserved |
| 17:19 | pre2act | Precharge to Active or Refresh delay.<br>Suggested value at 132 MHz = 0x02<br>Rule: $t_{RP}$/MEM_CLK-1. Round up to nearest integer.<br>EXAMPLE:<br>If $t_{RP}$ = 20ns and MEM_CLK = 99 MHz<br>20ns / 10.1 ns = 1.98; round to 2; write 0x1.<br>If $t_{RP}$ = 20 ns and MEM_CLK = 132 MHz<br>20ns / 7.5 ns = 2.66; round to 3; write 0x2. |
| 20:23 | ref2act | Refresh to Active delay.<br>Suggested value at 132 MHz = 0x9<br>Rule: $t_{RFC}$/MEM_CLK - 1. Round up to nearest integer.<br>EXAMPLE:<br>If $t_{RFC}$ = 75ns and MEM_CLK = 99 MHz<br>75ns / 10.1ns = 7.425; round to 8; write 0x7.<br>If $t_{RFC}$ = 75ns and MEM_CLK = 132 MHz<br>75ns / 7.5ns = 10; round to 9; write 0x9. |
| 24 | — | Reserved |
| 25:27 | wr_latency | Write latency.<br>For DDR, write 0x3<br>For SDR, write 0x0 |
| 28:31 | — | Reserved |

### 8.6.1.4 Memory Controller Configuration Register 2

The 32-bit read/write Configuration register 2 stores delay values necessary between specific SDRAM commands. During initialization, software loads values to the register according to the SDRAM information obtained from the data sheet. This register is reset only by a power-up reset signal.

The Burst Length field must be exact. All other fields govern the relative timing from one command to another, they have minimum values but any larger value is also legal (but with decreased performance).

All delays in this register are expressed in MEM_CLK.

Address MBAR + 0x010C

**Figure 8-6. Memory Controller Configuration Register 2**

**Table 8-11. Memory Controller Configuration Register 2 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | brd2rp | Burst Read to Read/Precharge delay. Limiting case is Read to Read.<br>For DDR, suggested value = 0x4 (BurstLength/2)<br>For SDR, suggested value = 0x8 (BurstLength) |
| 4:7 | bwt2rwp | Burst Write to Read/Write/Precharge delay. Limiting case is Write to Precharge.<br>For DDR, suggested value = 0x6 (BurstLength/2 + $t_{WR}$)<br>For SDR, suggested value = 0x8 (BurstLength + $t_{WR}$ - 2) |
| 8:11 | brd2wt | Burst Read to Read/Write/Precharge delay. Limiting case is Read to Write:<br>For DDR: CL + burstlength/2 + round trip delay + $t_{Hz}$ - 1.5 clk; round up.<br>If round trip delay = 1 clk and $t_{Hz}$ = 0.75 ns:<br>If CL==2: 2 + 4 + 1 + 0.75ns -1.5 = 5.5clk + 0.75ns, round to 0x6.<br>If CL==2.5: 2.5 + 4 + 1 + 0.75ns + 1.5 = 6clk + 0.75ns, round to 0x7.<br>For SDR: CL + burstlength + round trip delay + $t_{Hz}$ - 1 clk:<br>If CL==2: 2 + 8 + 1 + 5.4ns - 1 = 10clk + 5.4ns, round to 0xB.<br>If CL==3: 3 + 8 + 1 + 5.4ns - 1 = 11clk + 5.4ns, round to 0xC. |
| 12:15 | burst_length | Write 0x07 (Burst Length - 1) |
| 16:31 | — | Reserved |

Figure 8-7 shows the timings which can be programmed by the two Controller Configuration Register. The timing diagram uses the suggested values for a DDR memory and a 132 MHz memory clock. The displayed Commands are the limiting cases.

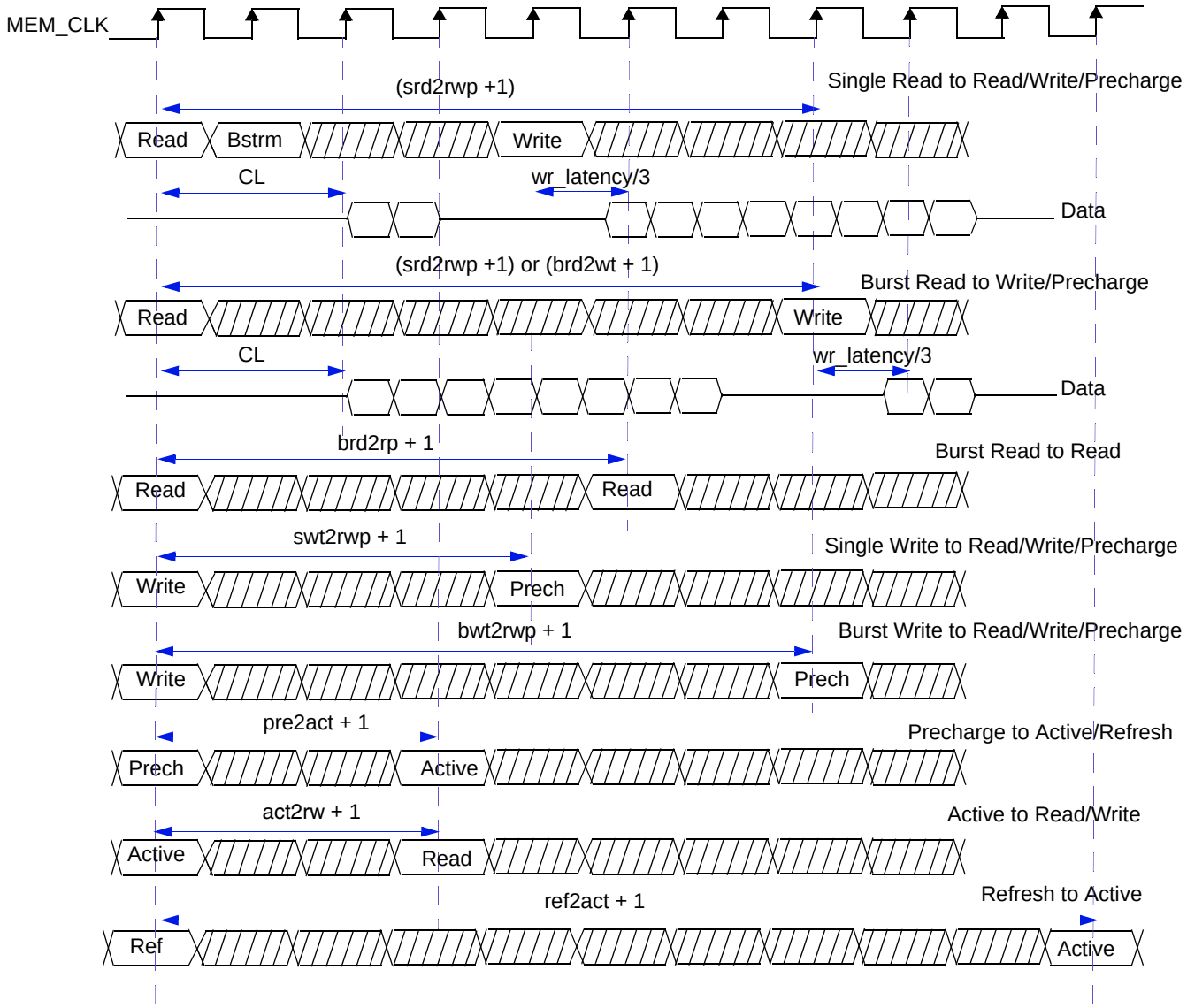



**Figure 8-7. Programmable Command Timings**

### 8.6.1.5 Special Configuration Delay Register

This Special Configuration Delay Register (SDelay) MUST be written to a value of 0x0000 0004.

Address MBAR + 0x0190

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | sdelay | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 8-8. Special Configuration Delay Register**

**Table 8-12. Special Configuration Delay Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 28:31 | sdelay | Special Configuration Delay—Must be written to 0x00000004 |

This register must be written to a value of 0x00000004. This is required to account for changes in delay caused during normal wafer processing.

For more information, see AN3221, *MPC5200B SDRAM Initialization and Configuration.*

# 8.7 Address Bus Mapping

This is an illustration of how the XL bus address enters the Memory Controller and is broken down into Row, Column, and Bank Address fields. Shown below is the 32-bit XL bus address. The Memory Controller uses bits 4:31.

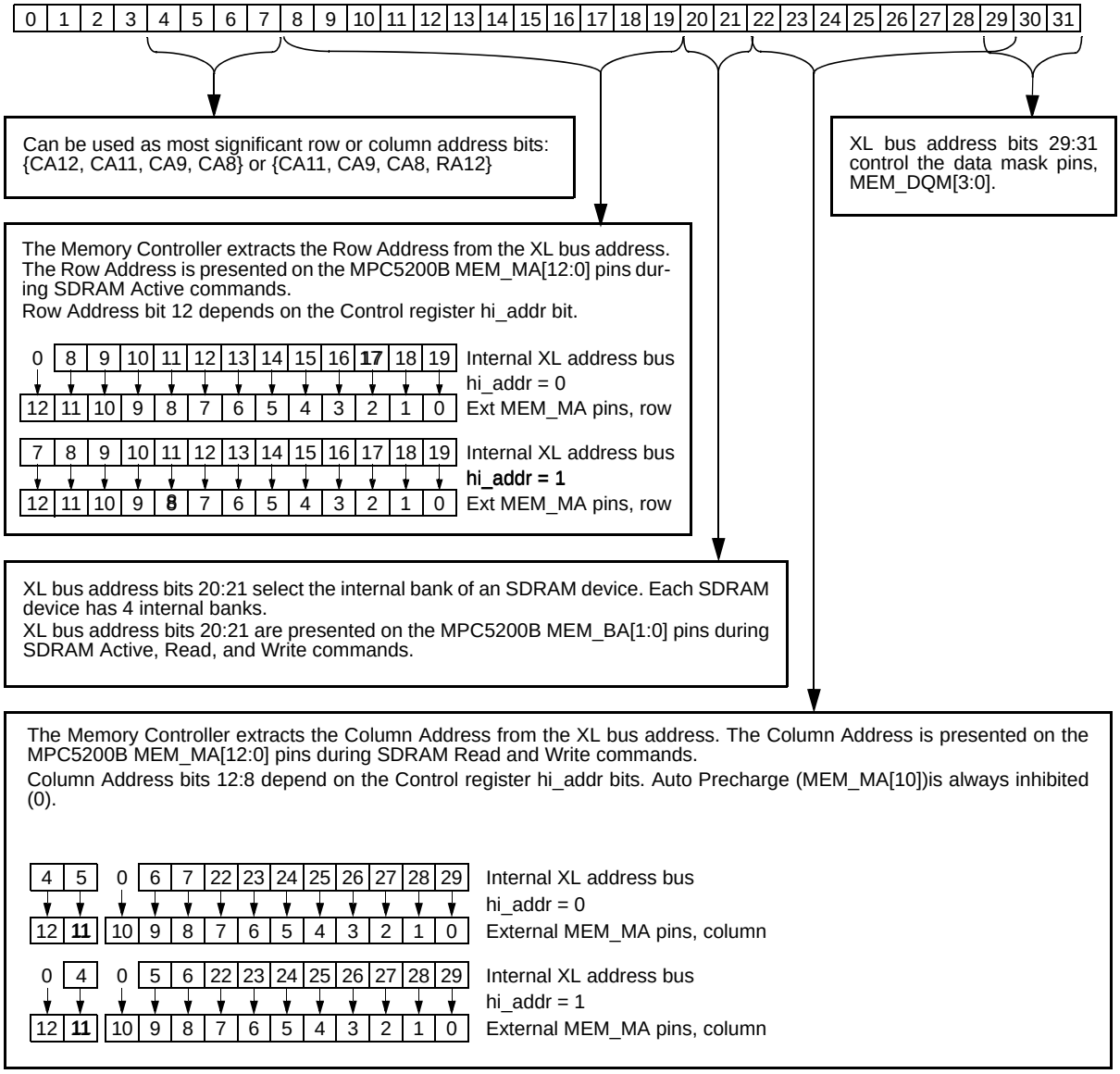

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Can be used as most significant row or column address bits: {CA12, CA11, CA9, CA8} or {CA11, CA9, CA8, RA12}
XL bus address bits 29:31 control the data mask pins, MEM_DQM[3:0].
The Memory Controller extracts the Row Address from the XL bus address. The Row Address is presented on the MPC5200B MEM_MA[12:0] pins during SDRAM Active commands.
Row Address bit 12 depends on the Control register hi_addr bit.
0 8 9 10 11 12 13 14 15 16 17 18 19
Internal XL address bus
hi_addr = 0
12 11 10 9 8 7 6 5 4 3 2 1 0
Ext MEM_MA pins, row
7 8 9 10 11 12 13 14 15 16 17 18 19
Internal XL address bus
hi_addr = 1
12 11 10 9 8 7 6 5 4 3 2 1 0
Ext MEM_MA pins, row
XL bus address bits 20:21 select the internal bank of an SDRAM device. Each SDRAM device has 4 internal banks.
XL bus address bits 20:21 are presented on the MPC5200B MEM_BA[1:0] pins during SDRAM Active, Read, and Write commands.
The Memory Controller extracts the Column Address from the XL bus address. The Column Address is presented on the MPC5200B MEM_MA[12:0] pins during SDRAM Read and Write commands.
Column Address bits 12:8 depend on the Control register hi_addr bits. Auto Precharge (MEM_MA[10])is always inhibited (0).
4 5 0 6 7 22 23 24 25 26 27 28 29
Internal XL address bus
hi_addr = 0
12 11 10 9 8 7 6 5 4 3 2 1 0
External MEM_MA pins, column
0 4 0 5 6 22 23 24 25 26 27 28 29
Internal XL address bus
hi_addr = 1
12 11 10 9 8 7 6 5 4 3 2 1 0
External MEM_MA pins, column

**Figure 8-9. Address Bus Mapping (32-Bit External Data Width)**

This is an illustration of how the XL bus address enters the Memory Controller and is broken down into Row, Column, and Bank Address fields. Shown below is the 32-bit XL bus address. The Memory Controller uses bits [27:0].

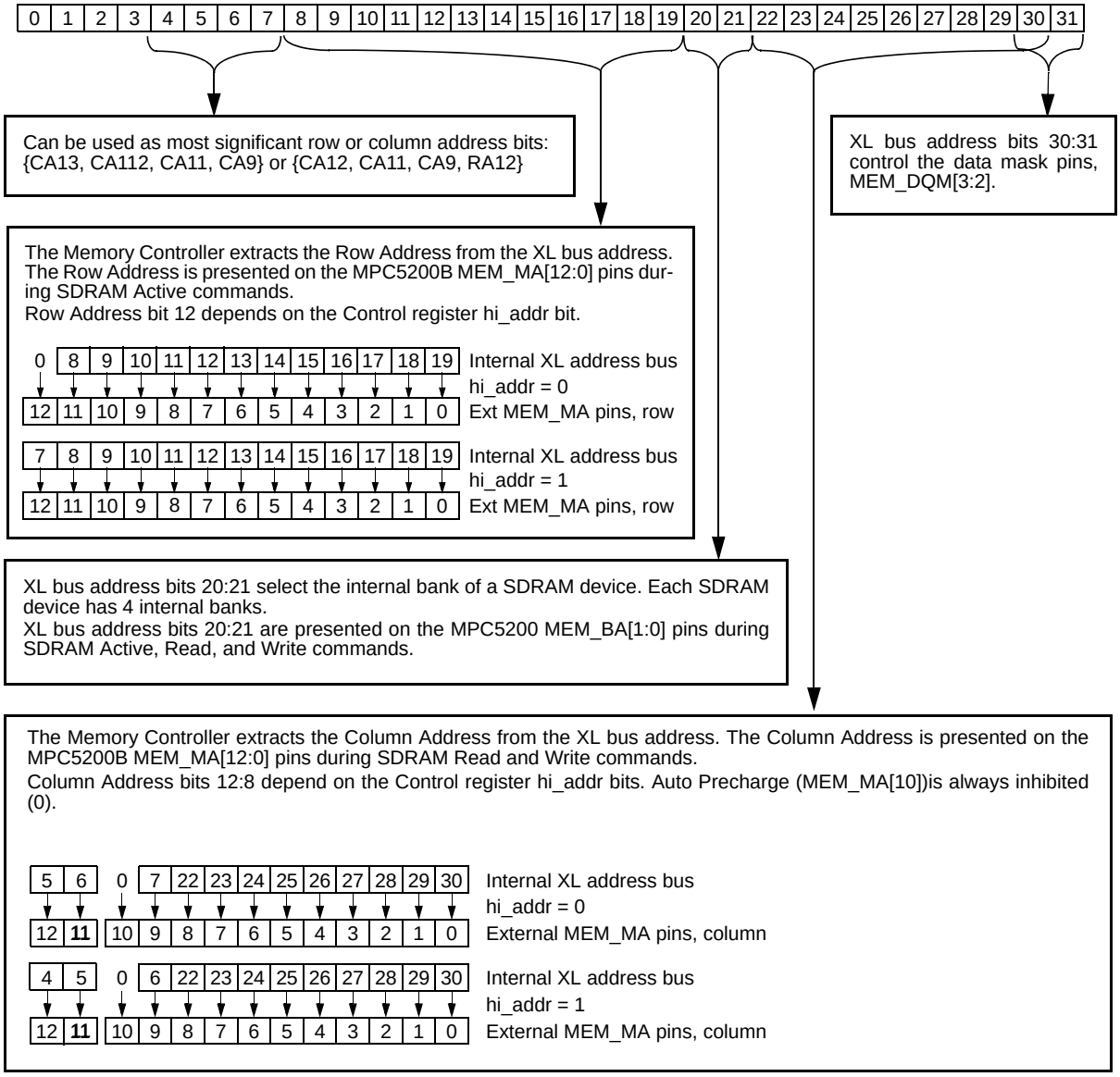

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Can be used as most significant row or column address bits: {CA13, CA112, CA11, CA9} or {CA12, CA11, CA9, RA12}
XL bus address bits 30:31 control the data mask pins, MEM_DQM[3:2].
The Memory Controller extracts the Row Address from the XL bus address. The Row Address is presented on the MPC5200B MEM_MA[12:0] pins during SDRAM Active commands.
Row Address bit 12 depends on the Control register hi_addr bit.
0 8 9 10 11 12 13 14 15 16 17 18 19
Internal XL address bus
hi_addr = 0
12 11 10 9 8 7 6 5 4 3 2 1 0
Ext MEM_MA pins, row
7 8 9 10 11 12 13 14 15 16 17 18 19
Internal XL address bus
hi_addr = 1
12 11 10 9 8 7 6 5 4 3 2 1 0
Ext MEM_MA pins, row
XL bus address bits 20:21 select the internal bank of a SDRAM device. Each SDRAM device has 4 internal banks.
XL bus address bits 20:21 are presented on the MPC5200 MEM_BA[1:0] pins during SDRAM Active, Read, and Write commands.
The Memory Controller extracts the Column Address from the XL bus address. The Column Address is presented on the MPC5200B MEM_MA[12:0] pins during SDRAM Read and Write commands.
Column Address bits 12:8 depend on the Control register hi_addr bits. Auto Precharge (MEM_MA[10])is always inhibited (0).
5 6 0 7 22 23 24 25 26 27 28 29 30
Internal XL address bus
hi_addr = 0
12 11 10 9 8 7 6 5 4 3 2 1 0
External MEM_MA pins, column
4 5 0 6 22 23 24 25 26 27 28 29 30
Internal XL address bus
hi_addr = 1
12 11 10 9 8 7 6 5 4 3 2 1 0
External MEM_MA pins, column

**Figure 8-10. Address Bus Mapping (16-Bit External Data Width)**

### 8.7.1 Example—Physical Address Multiplexing

The mapping of XL address bus to memory address bus is shown in Figure 8-9. The default mapping is:

- Row address comes from XLA[8:19]
- Column address comes from XLA[4:7, 22:29]
- Bank address comes from XLA[20:21]

Using the MT46V32M16 DDR SDRAM memory from Micron as an example, the device holds 512Mb organized as 8M x 16bit x 4banks. 2 devices are required to support the MPC5200B 32bit memory data bus, giving a total 128MB of address space (assuming just one $\overline{CS}$).

The Micron data sheet shows the following requirements:

- 13 row address bits
- 10 column address bits
- 2 bank select bits

By default, the Memory Controller only provides 12 row address bits and 12 column address bits. To enable the $13^{th}$ row address bit, the hi_addr bit of the Control register must be set to 1 (MBAR+0x0104, Control[7]). This also reduces the column address width to 11 bits.

# Chapter 9
# LocalPlus Bus (External Bus Interface)

## 9.1 Overview

The LocalPlus Bus is the external bus interface of the MPC5200B. This multi-function bus system supports interfacing to external Boot ROM or Flash memories, external SRAM memories or other memory mapped devices. The following sections are contained herein:


- Overview
- Features
- Interface
  - External Signals
  - Block Diagram
- Modes of Operation
  - Non-MUXed Mode
  - MUXed Mode
- Configuration
  - Boot Configuration
  - Chip Selects Configuration
  - Reset Configuration
- DMA (BestComm) Interface (SCLPC)
- Programmer's Model
  - Chip Select/LPC Registers
  - Chip Select/LPC Registers
  - SCLPC Registers
  - SCLPC FIFO Registers


The MPC5200B offers a shared external 32-bit address/data bus, which supports connections to PCI and ATA compliant devices, as well as memory mapped devices such as Flash memories, ROM, SRAM, gate-array logic, or other simple target (slave) devices with little or no additional circuitry. Separate control signals are used by each interface. The on-chip arbiter (called PCI Arbiter) controls the access to the shared AD bus for the different clients.

**NOTE**

If the PCI interface is NOT used (and internally disabled) the PCI control pins must be terminated as indicated by the PCI Local Bus specification. PCI control signals always require pull-up resistors on the motherboard (not the expansion board) to ensure that they contain stable values when no agent

is actively driving the bus. This includes PCI_FRAME, PCI_TRDY, PCI_IRDY, PCI_DEVSEL, PCI_STOP, PCI_SERR, PCI_PERR, and PCI_REQ.

The PCI signals, which are not used as address in Large Flash mode, are drive low during a Large Flash access. This includes PCI_SERR, PCI_PERR, PCI_IDSEL, PCI_REQ, PCI_GNT and PCI_RESET.

The PCI interface is described in Chapter 10, "PCI Controller". The ATA compliant interface is described in Chapter 11, "ATA Controller". The interface for memory mapped devices, called LocalPlus Bus, is described in this chapter. The MPC5200B LocalPlus Controller (LPC) module implements the LocalPlus Bus interface.

The LocalPlus Bus interface provides a high flexibility and all its different operating modes can be selected by means of software configuration and in some cases minimal external logic (in multiplexed mode).

## 9.2 Features

LocalPlus has the following features:

- Interface to memory mapped or chip selected devices
- Two main modes of operation:
  - — non-MUXed Modes
    - Legacy Modes (Address 8, 16, or 24 bits, Data 8 or 16 bits)
    - Most Graphics Mode (Address 24 bits, Data 32 bits)
    - Large Flash Mode (Address 26 bits, Data 8 or 16 bits)
  - — MUXed Modes
    - – (Address 8, 16, 24 or 25 bits, Data 8,16 or 32 bits, 2 Bank Selects)
- 8 Chip Select (CS) signals
  - — Programmable Wait States per CS
  - — Programmable Deadcycles per CS
  - — Programmable Byte Swapping per CS
- Configurable Boot interface supporting PowerPC architecture code execution
- Dynamic bus sizing on some interfaces
- Support of BURST MODE FLASH devices
- DMA (BestComm) support allows data movement independently from the CPU
- NO support of misaligned accesses

## 9.3 Interface

The LocalPlus interface consists of:

- Address bus
- Data bus
- Chip select signals CS0-7
- Control signals:
  - R/$\overline{W}$ (Read/Write)
  - $\overline{ALE}$ (Address Latch Enable)
  - $\overline{ACK}$ (Acknowledge)
  - $\overline{TS}$ (Transfer Start)
  - $\overline{OE}$ (Output Enable)
  - TSIZ bits (Transfer Size)
  - Bank Select bits
- Reference clock PCI_CLOCK

The reference clock PCI_CLOCK is always running, even if the PCI Controller is disabled.

### 9.3.1 External Signals

The external I/O bus is shared with the PCI AD bus and the ATA bus and requires arbitration for access to the external bus.

**Table 9-1. LocalPlus External Signals**

| Signal | I/O | Definition |
|---|---|---|
| $\overline{CS}$ [7:0] | O | Chip Selects (active low), $\overline{CS}$[4] and $\overline{CS}$[5] shared with ATA, $\overline{CS}$[6] and $\overline{CS}$[7] shared with PSC3. |
| R/$\overline{W}$ | O | Read/Write. 1 = Read, 0 = Write |
| EXT_AD[31:0] | I/O | AD Address / Data bus (bi-directional when used as data; bit 31=msb) |
| ACK | I/O | External Acknowledge input (non-burst transactions),<br>BURST indication for Most Graphics or Large Flash Modes (Open Drain) |
| TS | O | Transfer Start |
| OE | O | Output Enable |
| TSIZ[1:2] | O | Transfer Size<br>**Note:** TSIZ bits are available in non-muxed modes on GPIO_WKUP_7 and TEST_SEL_1 pins, if the LPTZ bit is set in Section 7.3.2.1.1, “GPS Port Configuration Register”<br>**Note:** The MUXed Mode provides 3 bits TSIZ[0:2], which are available on EX_AD[30:28]. |
| ALE | O | Address Latch Enable |

## 9.3.2 Block Diagram

The block diagram of the LocalPlus Controller (LPC) is shown in Figure 9-1. This diagram shows the non-multiplexed implementation of address and data lines.

The LPC is driven by the internal IP bus clock and the PCI_CLOCK. The supported ratios of the IP bus clock to the reference clock PCI_CLOCK (the one externally seen by peripherals) are 4:1, 2:1 and 1:1.

The reference clock is the PCI_CLOCK and all clock counts are referred to this clock. All transitions are synchronized to the rising edge of the PCI_CLOCK.

Start/Stop registers to define the CS address range for each CS output are contained in the MPC5200B MMAP register group, see Section 3.3.3.2, “Boot and Chip Select Addresses”. Registers in the LPC are accessed through the address range specified in the MPC5200B Internal Register Map. For more information, see Section 9.7, Programmer’s Model”. These registers control the operation of a particular CS and peripheral, when a hit occurs in the MMAP module for the corresponding CS space.

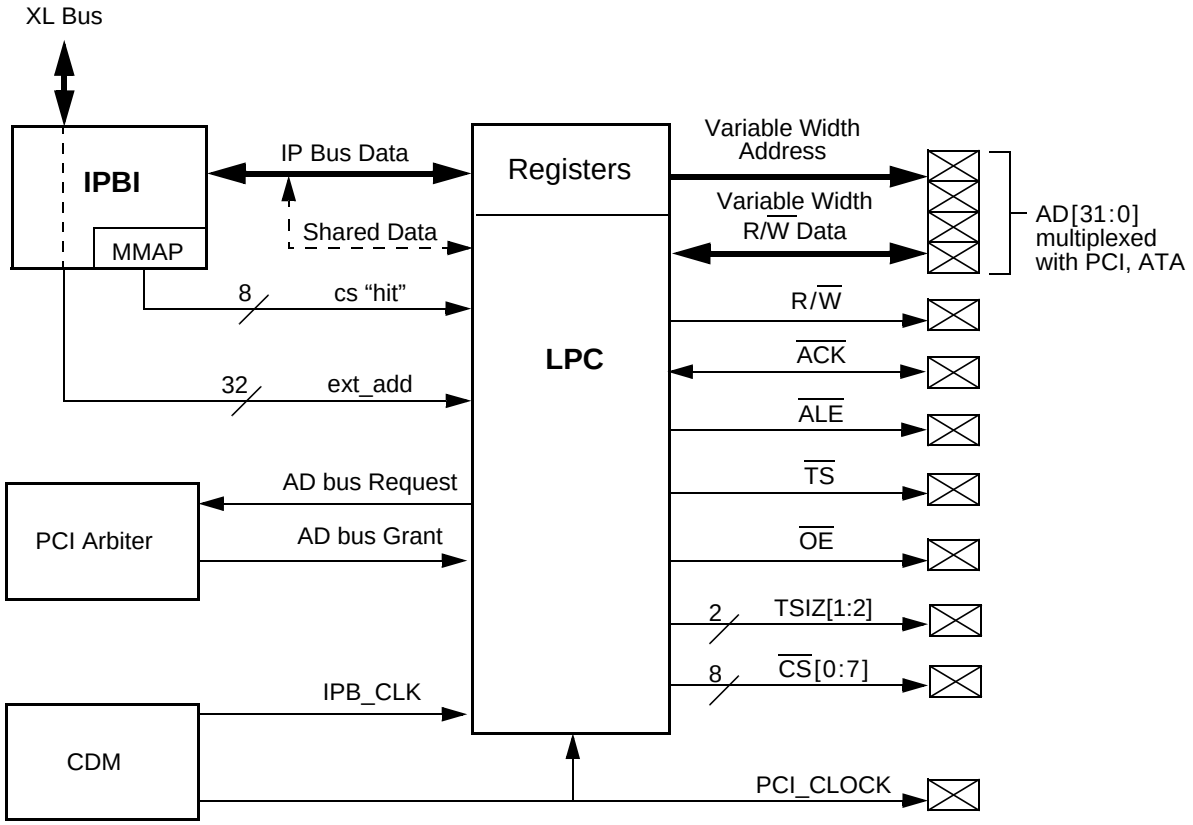



**Figure 9-1. LPC Concept Diagram**

**NOTE**

BestComm Interface + FiFo not shown

Not all pins are used in all modes.

For multiplexed bus implementation, external logic is required to capture the address phase as shown in Figure 9-2.

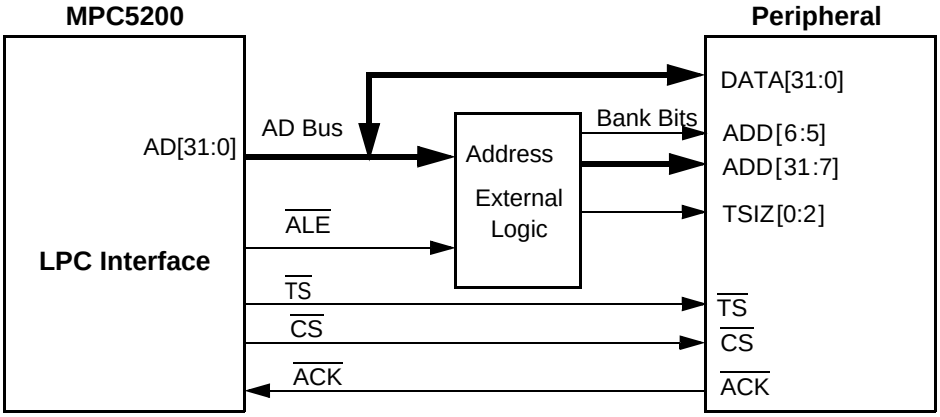



**Figure 9-2. Muxed Mode Address Latching**

## 9.4 Modes of Operation

There are 2 primary modes of operation:

- MUXed
- non-MUXed (Legacy, Large Flash, Most/Graphic modes, Burst and Non-Burst)

Within each mode, there is considerable flexibility to control the operation.

Each CS can be programmed to a different mode of operation (MUXed, non-MUXed, number of wait states, byte swapping etc.).

The MPC5200B always begins execution from the release of HRESET on the LocalPlus Bus and from the memory device connected to $\overline{CS}0$.

If an ATA Disk drive is present in the system, 2 CS signals may be taken up by the ATA interface. The ATA CSs can also be programmed to appear on other signals. For more information, see Chapter 11, “ATA Controller”.

MUXed mode allows devices with a larger address range be attached to the LocalPlus bus. In this mode the same 32-bit local bus presents an Address in an address tenure and Data in a data tenure, in a multiplexed fashion (similar to PCI protocol).

MUXed mode provides an $\overline{ALE}$ during the address phase and a $\overline{TS}$ during a separate data phase. This mode requires external logic to latch the address during the address tenure. An $\overline{ACK}$ input is provided and can be asserted to shorten (but not extend) wait states. The MUXed mode is available for all CSs, including CS0 (i.e., Boot Device).

The LocalPlus Bus on MPC5200B provides an Output Enable signal $\overline{OE}$ to achieve a complete glue less interface for most devices.

The logic equation for the internal generation of the $\overline{OE}$ signal is:

$$\overline{OE} = \overline{CSx} + (\text{NOT } R/\overline{W})$$

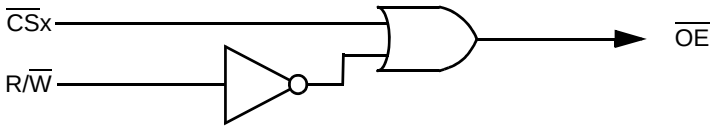



**Figure 9-3. Output Enable Signal**

MUXed and non MUXed modes support a variety of device configurations and are configurable on a per CS basis.

## 9.4.1 Non-MUXed Mode

In Non-MUXed mode the 32-bit address/data bus is divided into address and data lines. Eight different partitionings of address and data lines can be configured.

**Table 9-2. Non-Muxed Mode Options**

| Category | Address Size | Data Size | Pins used | Memory size | Comments |
|---|---|---|---|---|---|
| Small | 8 | 8 | 16 | 256 Bytes | Legacy Mode |
| Small | 8 | 16 | 24 | 256 Bytes | Legacy Mode |
| Small | 16 | 8 | 24 | 64 kBytes | Legacy Mode |
| Small | 16 | 16 | 32 | 64 kBytes | Legacy Mode (BOOT OPTION) |
| Medium | 24 | 8 | 32 | 16 MBytes | Legacy Mode (BOOT OPTION) |
| MOST/G | 24 | 32 | 56 | 16 MBytes | MOST Graphics (BOOT OPTION)<br>Burst support. No PCI or ATA support |
| Large | 26 | 8 | 34 | 64 MBytes | Large Flash Mode (BOOT OPTION). Burst support. No PCI support. |
| Large | 26 | 16 | 42 | 64 MBytes | Large Flash Mode (BOOT OPTION) Burst support. No PCI support |

**NOTE**

The 24-bit data width is **not** supported.

The total pin number requires also the addition of the control signals CS, R/$\overline{W}$, $\overline{ACK}$, $\overline{OE}$, $\overline{TS}$ (MOST/Graphis and Large Flash mode) and TSIZ (MOST/Graphics mode) where available.

The total supported memory size has been calculated taking into account that when accessing 16/32 bit devices A1 and/or A0 can NOT be used.

The above options defined as BOOT Option are selectable via the reset configuration word. Other configurations are possible via software configuration (e.g., 8-bit data and 16-bit address). Figure 9-4 shows the operation of Non-MUXed Read/Write accesses.

TSIZ bits are available in all non-muxed modes. They appear on GPIO_WKUP_7 (TSIZ most significant bit, TSIZ 1) and TEST_SEL_1 (TSIZ least significant bit, TSIZ 2), if the LPTZ bit is set in the GPS Port Configuration Register. Only TSIZEs of 1, 2, or 4 are supported.

TSIZ[1:2] are driven as follows:

01 = Transaction is 1 byte.

10 = Transaction is 2 bytes.

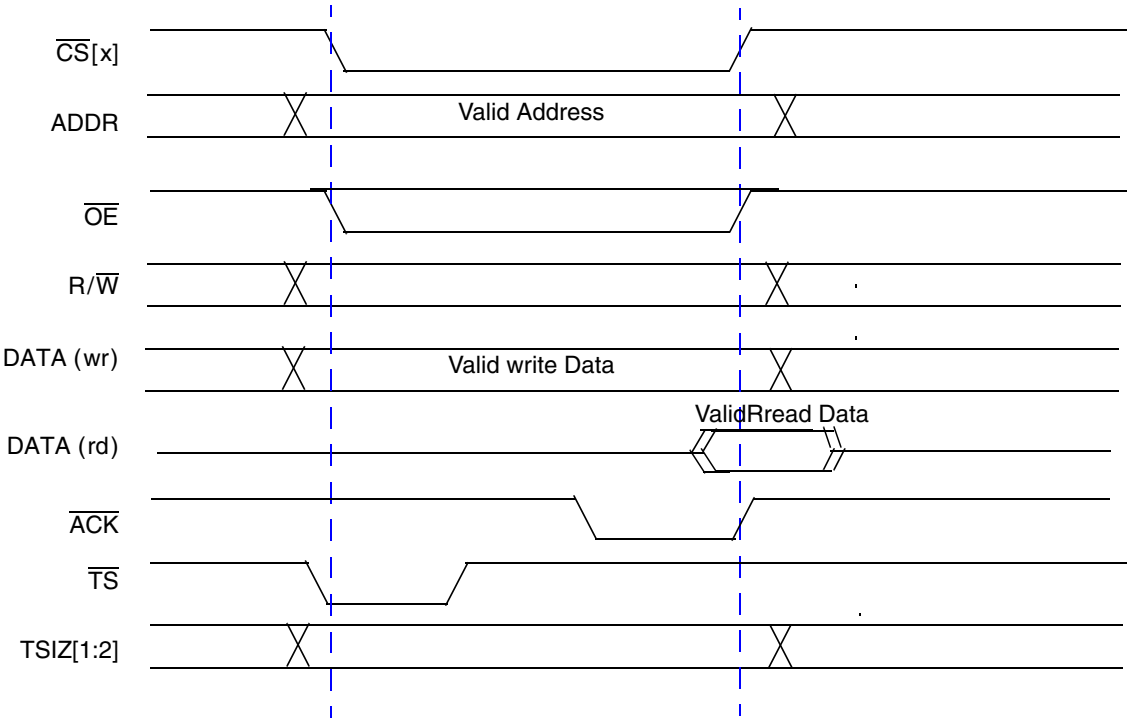
00 = Transaction is 4 bytes.

Other values are invalid and should not be required by the external peripheral!

Table 9-3 describes the various combinations of TSIZ, address and byte lanes for MOST/Graphis mode.

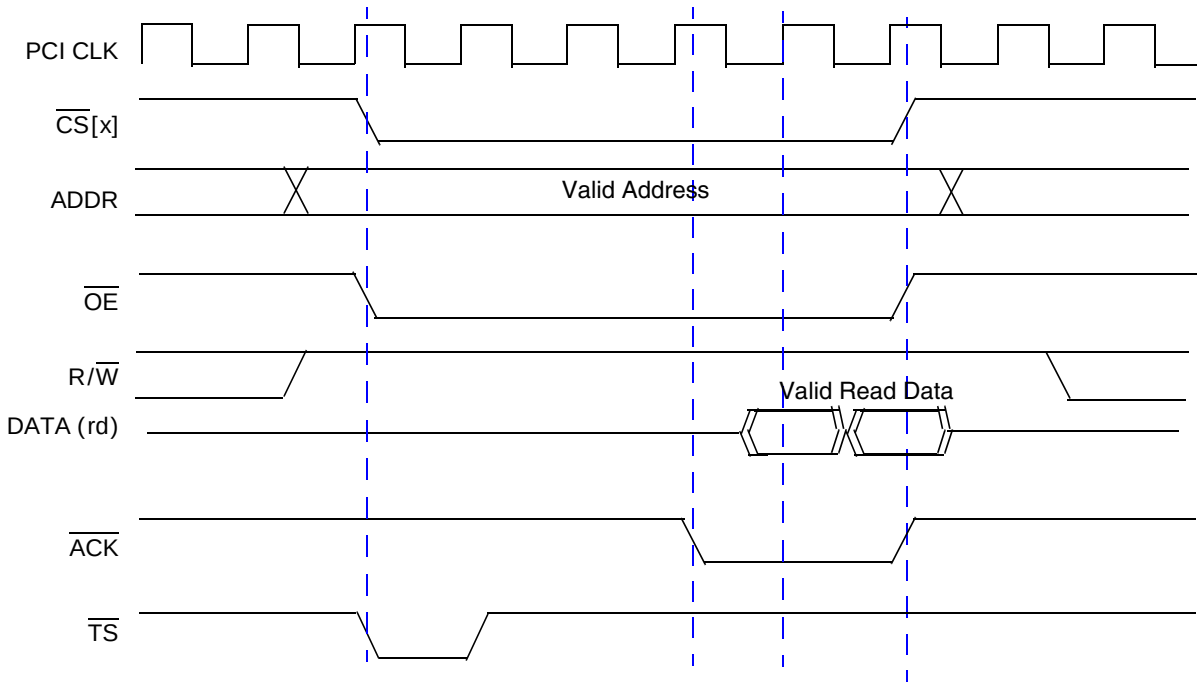
**Table 9-3. Non-Muxed Aligned Data Transfers**

| Transfer Size | TSIZ[1:2] | Addr[1:0] | Data lanes | | | |
|---|---|---|---|---|---|---|
| | | | AD[31:24] | AD[23:16] | AD[15:8] | AD[7:0] |
| 1 Byte | 01 | 00 | Data | — | — | — |
| | | 01 | — | Data | — | — |
| | | 10 | — | — | Data | — |
| | | 11 | — | — | — | Data |
| 2 Bytes | 10 | 00 | Data | Data | — | — |
| | | 10 | — | — | Data | Data |
| 4 Bytes | 00 | 00 | Data | Data | Data | Data |




NOTE:
1. ACK can shorten the CS pulse width.
2. TS is only available in Large Flash and MOST Graphics mode.

**Figure 9-4. Timing Diagram—Non-MUXed Mode**




NOTE:
1. Burst Mode is only available for Large Flash and MOST Graphics mode.
2. ACK is output and indicates the burst.

**Figure 9-5. Timing Diagram—Burst Mode**

In this mode, the peripheral address and data lines are limited to a total of 32 in Legacy Modes, to 40 or 48 in Large Flash or to 56 in MOST Graphics mode. They are driven/read simultaneously on the external AD bus. A single dedicated R/$\overline{W}$ pin is driven to indicate read or write. An individually dedicated CS pin is driven low while an external access is active.

Wait states are programmable and simply select how many PCI clocks the CS pin (and related signals) remain asserted. Separate values are available for Read cycles versus Write Cycles. These values can be combined to create extremely long (up to 16 bits) Write cycles. Byte lane swapping is separately programmable between Reads versus Writes and can be used to perform Endian conversions. The 24-bit data width is **not** supported.

Peripherals can be marked as read-only or write-only by setting a control bit in the appropriate LPC register. Attempted accesses in violation of this setting are prevented and result in either a Bus Error and/or an Interrupt as controlled by corresponding Enable bits. Each CS pin can be individually enabled/disabled and the entire LPC module has a Master Enable bit. No software reset bit is provided or needed.

The non-multiplexed mode requires no external logic for interfacing to simple devices such as Flash ROM, E2PROM or SRAM. It is faster than the multiplexed mode because data and address are provided in a single tenure. The supported address space is limited by the 26 address lines.

## 9.4.2 MUXed Mode

In MUXed mode the addresses and data are multiplexed using dual tenure. First, the address is put on the shared address/data bus and $\overline{\text{ALE}}$ is asserted. Then the data is driven when the chip select is asserted. Twelve different modes of address and data sizes can be configured:

**Table 9-4. MUXed Mode Options**

| Category | Address Size | Data Size | Memory Size per Bank | Memory Size Total | Comments |
|---|---|---|---|---|---|
| Legacy | 8 | 8 | 256 Bytes | 1 kBytes | |
| Legacy | 8 | 16 | 256 Bytes | 1 kBytes | A0 not used. |
| Legacy | 8 | 32 | 256 Bytes | 1 kBytes | A0, A1 not used. |
| Legacy | 16 | 8 | 64 kBytes | 256 kBytes | |
| Legacy | 16 | 16 | 64 kBytes | 256 kBytes | A0 not used. |
| Legacy | 16 | 32 | 64 kBytes | 256 kBytes | A0, A1 not used. |
| Legacy | 24 | 8 | 16 MBytes | 64 MBytes | |
| Legacy | 24 | 16 | 16 MBytes | 64 MBytes | A0 not used. |
| Legacy | 24 | 32 | 16 MBytes | 64 MBytes | A0, A1 not used. |
| Legacy | 25 | 8 | 32 MBytes | 128 MBytes | |
| Legacy | 25 | 16 | 32 MBytes | 128 MBytes | BOOT |
| Legacy | 25 | 32 | 32 MBytes | 128 MBytes | BOOT |

**NOTE**

The 24-bit data width is **not** supported.

The total supported Memory space consists of four banks.

Bank select bits are written in a register by the e300 processor. They can be used as individual selects or as encoded values. They are presented on the bus during the address tenure as additional upper address bits.

In this mode, an address tenure is generated that can be up to 25bits of active address. The additional address bits drive:

- a TSIZE value (3 bits)
- a Bank Select value (2 bits)

An ALE signal is asserted (active lo) during this address tenure. ALE width is always one PCI bus clock. The dedicated R/$\overline{\text{W}}$ output is also driven with ALE (and throughout the cycle). One clock after ALE negates, the appropriate CS pin asserts (low) and the AD bus enters the data tenure. The CS pin and this data tenure remain active until the programmed wait states expire, or the peripheral responds with an ACK assertion. ACK polarity is active low, but can be programmed to be ignored. The data tenure can contain up to the full 32-bit width. However, the data width is programmable to support dynamically bus-sized transactions.

The MUXed mode requires external logic to latch the address during the address tenure and to decode bank selects if they are encoded. This mode is slower than the non-MUXed mode because data and address are multiplexed in time. The supported address space is limited by the 25 address lines. In MUXed mode, LocalPlus can access up to 128 MBytes of data divided into four banks each of 32 MBytes maximum.

### 9.4.2.1 Address Tenure

The address is presented on the corresponding AD bus bits up to a maximum of 25bits (i.e., AD[24:0]). Smaller devices (with address ranges at 8, 16, or 24 respectively) must use the corresponding AD bits, beginning with AD[0]. AD[0] is the least significant address bit. Regardless of address size, the entire AD bus is driven during the address phase.

The Bank Select bits appear on AD[26] (Bank Select most significant bit) and AD[25] (Bank Select least significant bit). These bit values are pre-programmed into the corresponding LPC control register prior to initiating an external transaction.

The TSIZ bits appear on AD[30] (TSIZ most significant bit) to AD[28] (TSIZ least significant bit). These bits are calculated and driven by the LPC based on the internal Byte Lane enables on the IP bus.

**NOTE**

Only TSIZs of 1, 2, or 4 are supported.

TSIZ [0:2]/AD[30:28] are driven as follows:

001 = Transaction is 1 byte.

010 = Transaction is 2 bytes.

100 = Transaction is 4 bytes.

**NOTE**

Other values are invalid and should not be required by the external peripheral!

Table 9-5 describes the various combinations of TSIZ, address and byte lanes for 32 bit wide data bus.

**Table 9-5. Muxed Aligned Data Transfers**

| Transfer Size | TSIZ[0:2] | AD[1:0] | Data lanes | | | |
|---|---|---|---|---|---|---|
| | | | AD[31:24] | AD[23:16] | AD[15:8] | AD[7:0] |
| 1 Byte | 001 | 00 | Data | — | — | — |
| | | 01 | — | Data | — | — |
| | | 10 | — | — | Data | — |
| | | 11 | — | — | — | Data |
| 2 Bytes | 010 | 00 | Data | Data | — | — |
| | | 10 | — | — | Data | Data |
| 4 Bytes | 100 | 00 | Data | Data | Data | Data |

The ALE signal is active low and remains asserted for 1 external PCI bus clocks. When active any external latch should be transparent.

AD[31] & AD[27] are unused and are driven low by the LPC during the address tenure, they are used as data lines during the data phase in 32-bit modes.

#### 9.4.2.2 Data Tenure

During Data Tenure, the following occurs:

- In the case of a write to the peripheral, the LPC drives the indicated AD data bits.
- In the case of a read, the indicated AD bits are tri-stated by the LPC.

**NOTE**

AD[0] is treated as the least significant data bit. Any unused data bits (as indicated by the Data Size field in the associated control register) are driven low by the LPC. Therefore, they should NOT be driven by the peripheral or glue chip.

At the first PCI clock edge where the ACK input is detected as asserted, the LPC terminates the transaction and releases the bus on the **next** PCI Bus clock. AD bus control reverts to the PCI Controller, which is then responsible for driving default values on the bus. Obviously, any peripheral device **must** tri-state the AD bus when it is not in use.

Figure 9-6 shows a MUXed transaction type timing diagram.

## 9.5 Configuration

The LPC supports several options in terms of modes, address and data sizes, speed, and configuration which are described below.

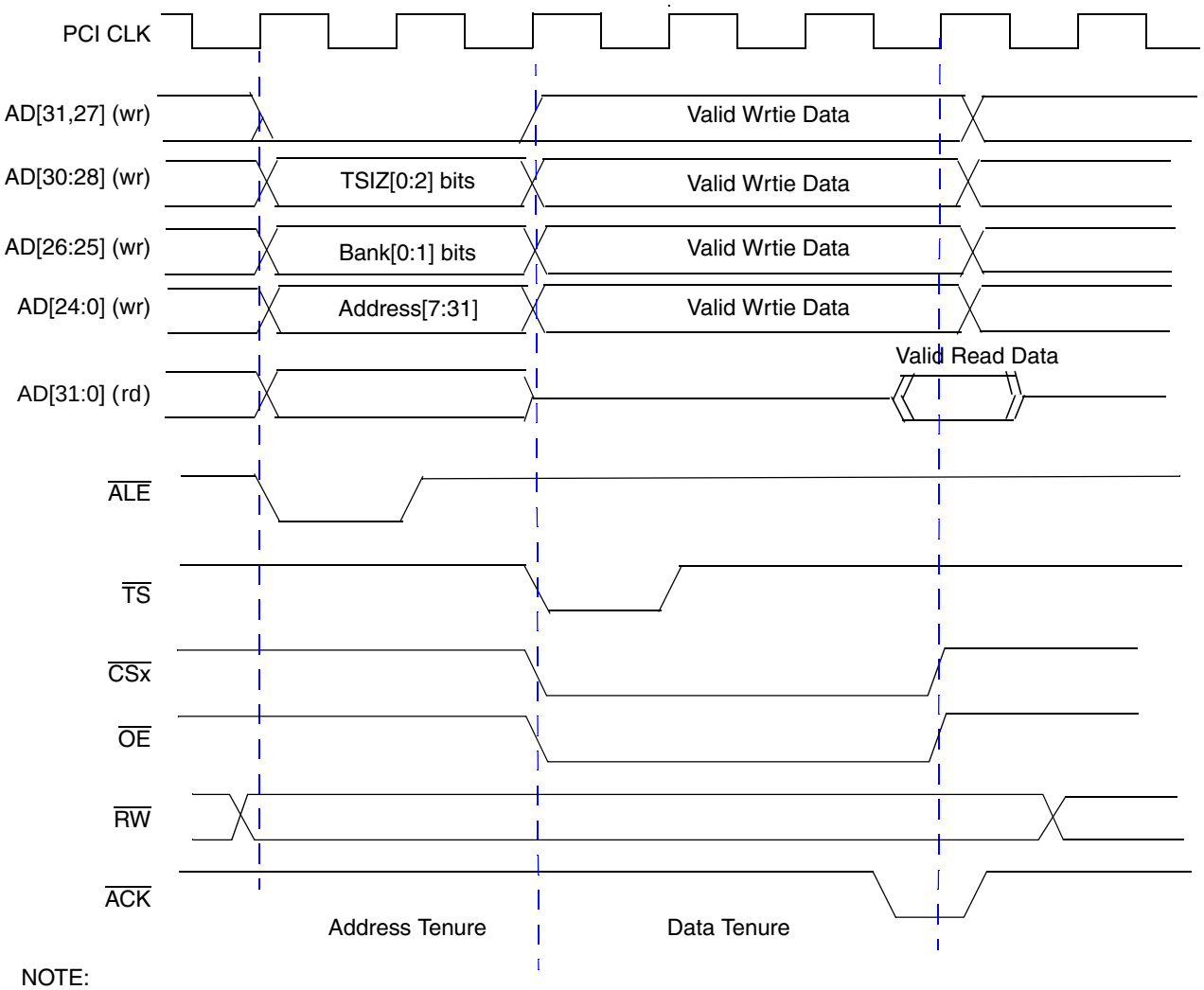
### 9.5.1 Boot Configuration

After power-on reset (POR) the e300 processor accesses the local bus to fetch initial code sequences. Chip Select Boot (CS Boot) is dedicated for this purpose. CS Boot and CS0 are physically the same pins. The difference is that CS Boot is impacted by the reset configuration and is enabled after reset.

Several options are also available for boot code fetches. The boot configuration is determined during POR using the reset_configuration word.

The following boot code configuration options are available, see Table 9-6.

- MUXed or non-MUXed mode.
  - — In MUXed mode Data bus can be 16- or 32-bits wide.
  - — In non-MUXed Legacy mode Data bus can be 8- or 16-bits wide.
  - — In non-MUXed MOST Graphics mode Data bus can be 32-bits wide.
  - — In non-MUXed Large Flash modes Data bus can be 8- or 16-bits wide.
- The number of wait states during boot can be 4 or 48 PCI bus clock cycles.
- The boot address/exception table can be located at 0x0000 0100 or 0xfff0 0100.




NOTE:
1. ACK can shorten the CS pulse width.
2. Address should be latched with the rising edge of ALE.

**Figure 9-6. Timing Diagram—MUXed Mode**

The PowerPC architecture compatible processor core requires 64-bit instruction fetches. During boot code accesses from CS Boot space on-chip logic is provided to perform enough LocalPlus accesses to accumulate 64-bit instructions to be given to the e300 processor. For example, before passing the resulting 64-bit instruction to the e300 processor, LocalPlus logic does either:

- 8 accesses to an 8-bit device
- 4 accesses to a 16-bit device
- 2 accesses to a 32-bit device

**NOTE**

The Boot space supports cached instruction reads and critical double word first transactions.

The Boot space does NOT support an 8-bit wide MUXed mode configuration during boot.

After boot, CS Boot space can be programmed to act as other MPC5200B Chip Select spaces (CS0-7). This capability is described in the sections below.

### 9.5.2 Chip Selects Configuration

All Chip Selects CS0-7 have the same functionality. Only one CS can be active at any given time. Multiple CS windows should not overlap. In the case that an address hit is located in multiple CS windows, only one CS, the one with the highest priority, becomes active. The CS with the lowest number has the highest priority (CS0 highest priority, CS7 lowest priority).

CS Boot and CS0 are identical with the exception of their control registers contained in the MPC5200B MMAP register group, see Section 3.3.3.2, “Boot and Chip Select Addresses”. CS Boot and CS0 are physically the same pins. The difference is that CS Boot is impacted by the reset configuration and is enabled after reset, so boot is always performed only at CS Boot.

To change from CS Boot to CS0 the CS0 start and stop addresses must be configured and the disable of CS Boot must occur together with the Enable of CS0 (see example).

```
ipbi->control_reg = (ipbi->control_reg & ~CSCTRL_BOOT_EN) | CSCTRL_CS0_EN;
```

Deadcycles from 0 to 3 can be added to any CS read access and will occur in addition to any cycles which already exist. The configuration of Dead cycles are done by the Chip Select Deadcycle Control Register.

Burst Mode operations are supported on all CS and can be configured by the Chip Select Burst Control Register.

The e300 processor can execute code from all CSs of the LP bus.

CS0-CS7 in MUXed mode:

- Supports 8-, 16- and 32-bit data reads and writes.
- Support of Dynamic bus sizing. This means read and write transactions greater than the defined port size are possible (up to a maximum of 32 bits).
- The LPC Controller creates multiple transactions at the defined port size to satisfy the transaction size requested up to a maximum of 32 bits. Transactions **less** than the defined port size are supported only if the peripheral can decode the TSIZE[0:2] bits, which indicate the current transaction size.
- 64-bit access is not supported. Internal logic is limited to 32-bits accesses.
- Support of Code execution

CS0-CS7 non-MUXed mode:

- In non-MUXed mode the data port size can be 8, 16 or 32 bits.
- Dynamic Bus Sizing for read and write transactions are supported at the defined port sizes. However, transactions that are **less** than the port size fail because no control signals exist to alert the peripheral to the current transaction size. TSIZE[1:2] bits are available in all non-muxed modes on separate pins, if the LPTZ bit is set in the GPS Port Configuration Register—MBAR + 0x0B00.
- Support of Burst access

### 9.5.3 Reset Configuration

The mode of the LocalPlus interface at boot is controlled by bits in the RST_CONFIG word described in Chapter 4, "Resets and Reset Configuration". The following 6 RST_CONFIG bits control boot device operation from reset:

- BootType
- BootSize
- BootMostGraphics
- BootLargeFlash
- BootWait
- BootSwap

Table 9-6 describes possible boot settings.

**Table 9-6. BOOT_CONFIG (RST_CONFIG) Options**

| Parameter | If Pulled Down (0) | If Pulled Up (1) | Notes |
|---|---|---|---|
| BootType | non-MUXed boot mode | MUXed boot mode | — |
| BootSize | non-MUXed type:<br>8-bit data<br>24-bit address | non-MUXed type:<br>16-bit data<br>16-bit address | — |
| | MUXed type:<br>16-bit data<br>(25 bit address) | MUXed type:<br>32-bit data<br>(25 bit address) | — |
| BootMostGraphics | — | MostGraphics boot mode. | — |
| LargeFlash | — | Large Flash boot mode | when active BootSize defines data size (8/16) |
| BootWait | Minimum Wait states<br>4 pci_clk cycles | Maximum Wait states:<br>48 pci_clk cycles | The ACK input can shorten wait states, if BootDevice supports it. |
| BootSwap | no Endian swapping applied to read from Boot Device | Standard Endian swapping performed on reads from Boot Device | If swap indicated:<br>8-bit access = no swap<br>16-bit access = 2Byte swap<br>32-bit access = 4Byte swap |

## 9.6 DMA (BestComm) Interface (SCLPC)

The SCLPC interface provides a separate path from BestComm directly (on CommBus) to any peripheral. The supported transactions are limited to 1, 2, 4, or 8 bytes only.

A single FIFO with a size of 512 bytes (32 x 128 bits) supports half duplex operation (Transmit or Receive) only. If software configures a Transmit Packet, the Packet must be complete before a Receive operation can be configured and started.

## 9.7 Programmer's Model

Figure 9-7 through Figure 9-12 describe in detail the registers and bit meanings for configuring CS operation. There are eight identical chip select configuration registers, one for each CS output. However, the CS Boot ROM Configuration Register has active defaults for use by BOOTROM on CS0. All other configuration registers power-up disabled and require software intervention before the corresponding CS operates. The Chip Select Control Register is the enable register and the Chip Select Status Register serves as a status register. For Burst Mode the Chip Select Burst Control Register exists and the configuration of Dead cycles are done by the Chip Select Deadcycle Control Register.

**NOTE**

The address range registers for each CS reside in the MMAP register set rather than in the LPC register set. See Section 3.3.3.2, "Boot and Chip Select Addresses".

### 9.7.1 Chip Select/LPC Registers

There are 12 32-bit Chip Select/LocalPlus (CS/LP) registers. These registers are located at an offset from MBAR of 0x0300. Register addresses are relative to this offset. Therefore, the actual register address is:
**MBAR + 0x0300 + register address**

The following registers are available:

- Chip Select 0/Boot Configuration Register (0x0300)
- Chip Select 1–7 Configuration Register (0x0304)
- Chip Select Control Register (0x0318)
- Chip Select Status Register (0x031C)
- Chip Select Burst Control Register (0x0328)
- Chip Select Deadcycle Control Register (0x032C)

### 9.7.1.1 Chip Select 0/Boot Configuration Register

Address MBAR + 0x0300

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | WaitP | | | | | | | | WaitX | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | cfg | cfg | cfg | cfg | cfg | cfg | cfg | cfg |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | MX | Rsvd | AA | CE | AS | | DS | | Bank | | WTyp | | WS | RS | WO | RO |
| Reset | cfg | 1 | 1 | 1 | cfg | cfg | cfg | cfg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Figure 9-7. Chip Select 0/Boot Configuration Register**

**Table 9-7. Chip Select 0/Boot Configuration Register Field Descriptions (Sheet 1 of 3)**

| Bits | Name | Description |
|---|---|---|
| 0:7 | WaitP | Number of wait states to insert. Can be applied as a prescale to WaitX or used by itself, as specified by WTyp bits below. Wait states control how many PCI clocks the corresponding CS pin remains active. |
| 8:15 | WaitX | Base number of wait states to insert, or combined with WaitP as specified by WTyp bits below.<br>**cfg operation**—If rstcfg[11] (on pad_eth_03) is zero then 4 wait states are in effect, else 48 wait states are in effect. Wait States equals the number of PCI clocks from CS assertion to when data must be valid from boot device. |
| 16 | MX | MX bit specifies whether a transaction operates as multiplexed or non-multiplexed. A multiplexed transaction presents address and data in different tenures. During the address tenure, $\overline{\text{ALE}}$ is asserted. At the end of $\overline{\text{ALE}}$, AD bus is switched to data tenure and $\overline{\text{CS}}$x pin is asserted.<br>0 = Non-multiplexed<br>1 = Multiplexed<br>**cfg operation**—If rstcfg[14] on pad_eth_06 is low, boot operation is non-multiplexed (single tenure), else boot operation is multiplexed (dual tenure). |
| 17 | — | Reserved |
| 18 | AA | ACK Active. This bit defines whether $\overline{\text{ALK}}$ input is active or not. If AA is 1, programmed wait states can be overridden when/if the external device drives the $\overline{\text{ACK}}$ input low. If AA is 0, the $\overline{\text{ACK}}$ input is ignored.<br>Wait states are still in effect. If no $\overline{\text{ACK}}$ is received, cycle terminates at end of wait state period.<br>**Note:** Bit must be set to 0, to use ACK as burst indication signal during a burst transaction. |
| 19 | CE | An individual Enable bit—allows CS operation for the corresponding CS pin. CE must be high to allow operation. Chip Select Control Register ME bit must also be high, except when CS[0] is used for boot ROM.<br>1 = Enable<br>0 = Disabled, register writes can occur but no external access is generated. |

**Table 9-7. Chip Select 0/Boot Configuration Register Field Descriptions (Sheet 2 of 3)**

| Bits | Name | Description |
|---|---|---|
| 20:21 | AS | Address Size field—defines size of peripheral Address bus (in bytes) and must be consistent with physical connections.<br>00 = 8 bits<br>01 = 16 bits<br>10 = 24 bits<br>11 = > 25 bits<br>See documentation for Physical Connection requirements.<br>The combination of address size, data size, and transaction type (MX) must be consistent with the peripheral physical connection. In case of a multiplexed transaction, the entire address is driven regardless of address size field.<br>**cfg operation**—If rstcfg[13] on pad_eth_05 is low, then the address size for non-multiplexed boot device is set to 24 bits (AS=10), else the boot device is treated as a 16 bit address (AS=01) device. For multiplexed mode boot devices the maximum 25 bits of address is always driven. This rstcfg bit more particularly affects the DS field below, and can be thought of as the “small” or “big” data size config bit. |
| 22:23 | DS | Data Size field—represents the peripheral data bus size (in bytes):<br>00 = 1 Byte<br>01 = 2 Bytes<br>10 = 3 Bytes (**Not Supported**)<br>11 = 4 Bytes<br>**cfg operation**—If rstcfg[13] on pad_eth_05 is low, then the data size for non-multiplexed boot device is set to 8 bits (DS=00), else the boot device is treated as a 16 bit (DS=01) device. For multiplexed mode boot device the selection is 16 bit data or 32 bit data respectively. |
| 24:25 | Bank | Bank bits—are reflected on external AD lines (AD[26:25]) during Address tenure of a multiplexed transaction. Register bit 24 is the msb and appears on AD[26]. |
| 26:27 | WTyp | Wait state Type bits—define the application of wait states contained in WaitP and WaitX fields, as follows:<br>00 = WaitX is applied to read and write cycles (WaitP is ignored).<br>01 = WaitX is applied to Read cycles, WaitP is applied to Write cycles.<br>10 = WaitX is applied to Reads, WaitP/WaitX (16-bit value) is applied to Writes.<br>11 = WaitP/Waitx (as a full 16-bit value) is applied to Reads and Writes. |
| 28 | WS | Write Swap bit—If high, Endian byte swapping occurs during writes to a peripheral.<br>• For 8-bit peripherals, this bit has no effect.<br>• For 16-bit peripherals, byte swapping can occur.<br>• For 32-bit peripherals (possible in MUXed mode only) byte swap can occur.<br>1 = swap<br>0 = NO swap<br>2-byte swap is AB to BA, 4-byte swap is ABCD to DCBA.<br>**Note:** Transactions at less than the defined port size (i.e., data size) apply swap rules as above, according to the current transaction size. |
| 29 | RS | Read Swap bit—Same as WS, but swapping is done when reading data from a peripheral.<br>1 = swap<br>0 = NO swap<br>**cfg operation**—If rstcfg[12] on pad_eth_04 is low, data from the boot device is Endian swapped when read. This only has effect for boot devices configured as 16- or 32-bit data size. |

**Table 9-7. Chip Select 0/Boot Configuration Register Field Descriptions (Sheet 3 of 3)**

| Bits | Name | Description |
|---|---|---|
| 30 | WO | Write Only bit—If bit is high, the peripheral is treated as a write-only device. An attempted read access results in a bus error (as dictated by Chip Select Control Register EBEE bit) and/or an interrupt (as dictated by Chip Select Control Register IE bit). In any case, no transaction is presented to the peripheral.<br>A bus error means the internal cycle is terminated with a transfer error acknowledge (ips_xfr_err assertion to IP bus, TEA assertion to XL bus). |
| 31 | RO | Read Only bit—If bit is high, the peripheral is treated as a read-only device. An attempted write access results in a bus error (as specified by Chip Select Control Register EBEE bit) and/or an interrupt (as specified by Chip Select Control Register IE bit). In any case, no transaction is presented to the peripheral.<br>**NOTE:** This bit is high from Reset, indicating Boot Device is Read-Only. |

**Note:**

1. The reset values defined as cfg depends on the Reset Configuration.
2. Large Flash mode is used, if AS is set to 11 and DS is set to 00 or 01.
3. MOST/Graphics mode is used, if AS is set to 10 and DS is set to 11.

## 9.7.1.2 Chip Select 1–7 Configuration Register

Address MBAR + 0x0304, 0x0308, 0x030C, 0x310, 0x0314, 0x0320, 0x0324

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | WaitP | | | | | | | | WaitX | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | cfg | cfg | cfg | cfg | cfg | cfg | cfg | cfg |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | MX | Rsvd | AA | CE | AS | | DS | | Bank | | WTyp | | WS | RS | WO | RO |
| Reset | cfg | 1 | 1 | 1 | cfg | cfg | cfg | cfg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Figure 9-8. Chip Select 1–7 Configuration Register**

**Table 9-8. Chip Select 1–7 Configuration Register Field Descriptions (Sheet 1 of 3)**

| Bits | Name | Description |
|---|---|---|
| 0:7 | WaitP | Number of Wait States to insert. Can be applied as a prescale to Wait X or used by itself, as dictated by the WTyp bits (see below). Wait States control how many PCI clocks the corresponding CS pin remains active. |
| 8:15 | WaitX | The base number of wait states to insert, or combined with WaitP as dictated by the WTyp bits below. |
| 16 | MX | MX bit specifies whether transaction operates as multiplexed or non-multiplexed. A multiplexed transaction presents address and data in different tenures. During the address tenure, $\overline{ALE}$ is asserted. At the end of $\overline{ALE}$, AD bus is switched to data tenure and $\overline{CS}$x pin is asserted.<br>0 = Non-multiplexed<br>1 = Multiplexed |

**Table 9-8. Chip Select 1–7 Configuration Register Field Descriptions (Sheet 2 of 3)**

| Bits | Name | Description |
|---|---|---|
| 17 | — | Reserved |
| 18 | AA | ACK Active. This bit defines whether $\overline{ALK}$ input is active or not. If AA is 1, programmed wait states can be overridden when/if the external device drives the $\overline{ACK}$ input low. If AA is 0, the $\overline{ACK}$ input is ignored.<br>Wait states are still in effect. If no $\overline{ACK}$ is received, cycle terminates at end of wait state period.<br>**Note:** Bit must be set to 0, to use ACK as burst indication signal during a burst transaction. |
| 19 | CE | Chip Enable—bit allows CS operation for the corresponding CS pin. Must be high to allow operation. Chip Select Control Register ME bit must also be high.<br>Enabled.<br>0 = Disabled, register writes can occur but no external access is generated. |
| 20:21 | AS | Address Size field—defines the peripheral address bus size in bytes, and must be consistent with the physical connections.<br>00 = 8 bits<br>01 = 16 bits<br>10 = 24 bits<br>11 = > 25 bits<br>**Note:** The combination of address size, data size, and transaction type (MX) must be consistent with the physical peripheral connection. In a multiplexed transaction, the entire address is driven, regardless of the address size field. |
| 22:23 | DS | Data Size field—represents the peripheral data bus size (in bytes):<br>00 = 1 Byte<br>01 = 2 Bytes<br>10 = 3 Bytes (**Not Supported**)<br>11 = 4 Bytes |
| 24:25 | Bank | Bank bits—are reflected on external AD lines (AD[26:25]) during address tenure of a multiplexed transaction. Register bit 24 is the msb and appears on AD[26]. |
| 26:27 | WTyp | Wait state Type bits—define application of wait states contained in WaitP and WaitX fields, as follows:<br>00 = WaitX is applied to Read and Write cycles (WaitP is ignored)<br>01 = WaitX is applied to Read cycles, WaitP is applied to Write cycles<br>10 = WaitX is applied to Reads, WaitP/WaitX (16-bit value) is applied to Writes<br>11 = WaitP/Waitx (as a full 16-bit value) is applied to Reads and Writes |
| 28 | WS | Write Swap bit—If high, Endian byte swapping occurs during writes to a peripheral.<br>• For 8-bit peripherals, this bit has no effect.<br>• For 16-bit peripherals, byte swapping can occur.<br>• For 32-bit peripherals (possible in MUXed mode only) byte swap can occur.<br>1 = swap<br>0 = NO swap<br>2-byte swap is AB to BA, 4-byte swap is ABCD to DCBA.<br>**Note:** Transactions at less than the defined port size (i.e., data size) apply swap rules as above, according to the current transaction size. |

**Table 9-8. Chip Select 1–7 Configuration Register Field Descriptions (Sheet 3 of 3)**

| Bits | Name | Description |
|---|---|---|
| 29 | RS | Read Swap bit—Same as WS, but swapping is done when reading data from a peripheral.<br>1 = swap<br>0 = NO swap<br>**Note:** Transactions at less than the defined port size (i.e., data size) apply swap rules as above, according to the current transaction size. |
| 30 | WO | Write Only bit—If high peripheral is treated as a write-only device. An attempted Read access results in a bus error (as specified by Chip Select Control Register EBEE bit) and/or an interrupt (as dictated by Chip Select Control Register IE bit). In any case, no transaction is presented to the peripheral.<br>A bus error means the internal cycle is terminated with a transfer error acknowledge (ips_xfr_err assertion to IP bus, TEA assertion to XL bus). |
| 31 | RO | Read Only bit—If high, peripheral is treated as a read-only device. An attempted Write access results in a bus error (as specified by Chip Select Control Register EBEE bit) and/or an interrupt (as dictated by Chip Select Control Register IE bit). In any case, no transaction is presented to the peripheral. |

**Note:**

1. Large Flash mode is used, if AS is set to 11 and DS is set to 00 or 01.
2. MOST Graphics mode is used, if AS is set to 10 and DS is set to 11.

## 9.7.1.3 Chip Select Control Register

Address MBAR +
0x0318

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | ME | Reserved | | | | | | | |
| Reset: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 9-9. Chip Select Control Register**

**Table 9-9. Chip Select Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7 | ME | Master Enable bit—a global module enable bit. If this bit is low, register access can still occur, but no external transactions are accepted. However, ME does not affect boot ROM operation on $\overline{CS}$[0]. If software wishes to disable $\overline{CS}$[0], it must write 0 to the Chip Select Boot ROM Configuration Register enable bit (CE). |
| 8:31 | — | Reserved |

### 9.7.1.4 Chip Select Status Register

Address MBAR + 0x031C

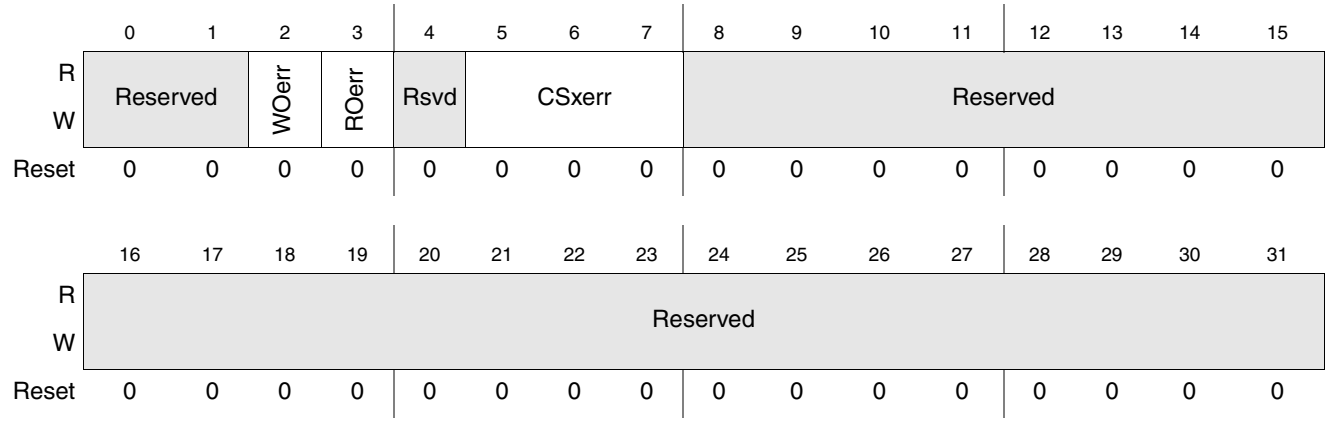



**Figure 9-10. Chip Select Status Register**

**Table 9-10. Chip Select Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2 | WOerr | Write Only error—If 1, it indicates a Read access was attempted on a peripheral marked as write-only.<br>This is a sticky bit and must be written with 1 to be cleared. This status bit is always active regardless of bus error enable bit. The CS number that relates to the error is reflected in the CSxerr field. |
| 3 | ROerr | Read Only error—If 1, it indicates a Write access was attempted on a peripheral marked as read-only.<br>This is a sticky bit and must be written with 1 to be cleared. This status bit is always active regardless of bus error enable bit. The CS number that relates to the error is reflected in the $\overline{\text{CS}}$xerr field. |
| 4 | — | Reserved |
| 5:7 | CSxerr | Chip Select error—Indicates CS number associated with WOerr or ROerr. |
| 8:31 | — | Reserved |

### 9.7.1.5 Chip Select Burst Control Register

Address MBAR + 0x0328

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | CW7 | SLB7 | Rsvd | BRE7 | CW6 | SLB6 | Rsvd | BRE6 | CW5 | SLB5 | Rsvd | BRE5 | CW4 | SLB4 | Rsvd | BRE4 |
| Reset: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | CW3 | SLB3 | Rsvd | BRE3 | CW2 | SLB2 | Rsvd | BRE2 | CW1 | SLB1 | Rsvd | BRE1 | CW0 | SLB0 | Rsvd | BRE0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 9-11. Chip Select Burst Control Register**

**Table 9-11. Chip Select Burst Control Register Field Descriptions (Sheet 1 of 3)**

| Bits | Name | Description |
|---|---|---|
| 0 | CW7 | Chip Select 7 Cache Wrap capable, set if peripheral burst can perform PPC cache wrap. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 1 | SLB7 | Chip Select 7 Short/Long Burst, 0 for Short Burst only, 1 for Long Burst capable. Short burst is 8-bytes, used for Instruction fetches, and CDWF cache line bursts on XLB if cache wrap not capable. Long Burst capable means that peripheral can do 32-byte burst which hardware will generate for cache line aligned XLB bursts (and CDWF if peripheral tagged as cache wrap capable also). This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 2 | — | Reserved |
| 3 | BRE7 | Chip Select 7 Burst Read Enable, 1 to enable peripheral bursting for given chip select. Must be set to enable any Bursting reads. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 4 | CW6 | Chip Select 6 Cache Wrap capable, set if peripheral burst can perform PPC cache wrap. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 5 | SLB6 | Chip Select 6 Short/Long Burst, 0 for Short Burst only, 1 for Long Burst capable. Short burst is 8-bytes, used for Instruction fetches, and CDWF cache line bursts on XLB if cache wrap not capable. Long Burst capable means that peripheral can do 32-byte burst which hardware will generate for cache line aligned XLB bursts (and CDWF if peripheral tagged as cache wrap capable also). This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 6 | — | Reserved |
| 7 | BRE6 | Chip Select 6 Burst Read Enable, 1 to enable peripheral bursting for given chip select. Must be set to enable any Bursting reads. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 8 | CW5 | Chip Select 5 Cache Wrap capable, set if peripheral burst can perform PPC cache wrap. This bit setting only applies in Large Flash or MOST Graphics Mode. |

**Table 9-11. Chip Select Burst Control Register Field Descriptions (Sheet 2 of 3)**

| Bits | Name | Description |
|---|---|---|
| 9 | SLB5 | Chip Select 5 Short/Long Burst, 0 for Short Burst only, 1 for Long Burst capable. Short burst is 8-bytes, used for Instruction fetches, and CDWF cache line bursts on XLB if cache wrap not capable. Long Burst capable means that peripheral can do 32-byte burst which hardware will generate for cache line aligned XLB bursts (and CDWF if peripheral tagged as cache wrap capable also). This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 10 | — | Reserved |
| 11 | BRE5 | Chip Select 5 Burst Read Enable, 1 to enable peripheral bursting for given chip select. Must be set to enable any Bursting reads. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 12 | CW4 | Chip Select 4 Cache Wrap capable, set if peripheral burst can perform PPC cache wrap. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 13 | SLB4 | Chip Select 4 Short/Long Burst, 0 for Short Burst only, 1 for Long Burst capable. Short burst is 8-bytes, used for Instruction fetches, and CDWF cache line bursts on XLB if cache wrap not capable. Long Burst capable means that peripheral can do 32-byte burst which hardware will generate for cache line aligned XLB bursts (and CDWF if peripheral tagged as cache wrap capable also). This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 14 | — | Reserved |
| 15 | BRE4 | Chip Select 4 Burst Read Enable, 1 to enable peripheral bursting for given chip select. Must be set to enable any Bursting reads. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 16 | CW3 | Chip Select 3 Cache Wrap capable, set if peripheral burst can perform PPC cache wrap. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 17 | SLB3 | Chip Select 3 Short/Long Burst, 0 for Short Burst only, 1 for Long Burst capable. Short burst is 8-bytes, used for Instruction fetches, and CDWF cache line bursts on XLB if cache wrap not capable. Long Burst capable means that peripheral can do 32-byte burst which hardware will generate for cache line aligned XLB bursts (and CDWF if peripheral tagged as cache wrap capable also). This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 18 | — | Reserved |
| 19 | BRE3 | Chip Select 3 Burst Read Enable, 1 to enable peripheral bursting for given chip select. Must be set to enable any Bursting reads. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 20 | CW2 | Chip Select 2 Cache Wrap capable, set if peripheral burst can perform PPC cache wrap. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 21 | SLB2 | Chip Select 2 Short/Long Burst, 0 for Short Burst only, 1 for Long Burst capable. Short burst is 8-bytes, used for Instruction fetches, and CDWF cache line bursts on XLB if cache wrap not capable. Long Burst capable means that peripheral can do 32-byte burst which hardware will generate for cache line aligned XLB bursts (and CDWF if peripheral tagged as cache wrap capable also). This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 22 | — | Reserved |
| 23 | BRE2 | Chip Select 2 Burst Read Enable, 1 to enable peripheral bursting for given chip select. Must be set to enable any Bursting reads. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 24 | CW1 | Chip Select 1 Cache Wrap capable, set if peripheral burst can perform PPC cache wrap. This bit setting only applies in Large Flash or MOST Graphics Mode. |

**Table 9-11. Chip Select Burst Control Register Field Descriptions (Sheet 3 of 3)**

| Bits | Name | Description |
|---|---|---|
| 25 | SLB1 | Chip Select 1 Short/Long Burst, 0 for Short Burst only, 1 for Long Burst capable. Short burst is 8-bytes, used for Instruction fetches, and CDWF cache line bursts on XLB if cache wrap not capable. Long Burst capable means that peripheral can do 32-byte burst which hardware will generate for cache line aligned XLB bursts (and CDWF if peripheral tagged as cache wrap capable also). This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 26 | — | Reserved |
| 27 | BRE1 | Chip Select 1 Burst Read Enable, 1 to enable peripheral bursting for given chip select. Must be set to enable any Bursting reads. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 28 | CW0 | Chip Select 0 Cache Wrap capable, set if peripheral burst can perform PPC cache wrap. This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 29 | SLB0 | Chip Select 0 Short/Long Burst, 0 for Short Burst only, 1 for Long Burst capable. Short burst is 8-bytes, used for Instruction fetches, and CDWF cache line bursts on XLB if cache wrap not capable. Long Burst capable means that peripheral can do 32-byte burst which hardware will generate for cache line aligned XLB bursts (and CDWF if peripheral tagged as cache wrap capable also). This bit setting only applies in Large Flash or MOST Graphics Mode. |
| 30 | — | Reserved |
| 31 | BRE0 | Chip Select 0 Burst Read Enable, 1 to enable peripheral bursting for given chip select. Must be set to enable any Bursting reads. This bit setting only applies in Large Flash or MOST Graphics Mode. |

**Note:**

1. CDWF is defined as critical double word first.
2. The bits for Chip Select 0 (CS0) control CS Boot too.
3. With a clock ratio 1:1:1 (66:66:66 MHz) it is not possible to burst in Large Flash mode.

### 9.7.1.6 Chip Select Deadcycle Control Register

Address MBAR + 0x032C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | DC7 | | Reserved | | DC6 | | Reserved | | DC5 | | Reserved | | DC4 | |
| Reset | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | DC3 | | Reserved | | DC2 | | Reserved | | DC1 | | Reserved | | DC0 | |
| Reset | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |

**Figure 9-12. Chip Select Deadcycle Control Register**

**Table 9-12. Chip Select Deadcycle Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2:3 | DC7 | Deadcycles can be specified as 0 to 3. Dead cycles will be added to the end of Chip Select 7 read access and will occur in addition to any cycles which may already exist. These cycles are to provide peripheral additional time to tri-state it's bus after a read operation. This is for all access types. |
| 4:5 | — | Reserved |
| 6:7 | DC6 | Deadcycles can be specified as 0 to 3. Dead cycles will be added to the end of Chip Select 6 read access and will occur in addition to any cycles which may already exist. These cycles are to provide peripheral additional time to tri-state it's bus after a read operation. This is for all access types. |
| 8:9 | — | Reserved |
| 10:11 | DC5 | Deadcycles can be specified as 0 to 3. Dead cycles will be added to the end of Chip Select 5 read access and will occur in addition to any cycles which may already exist. These cycles are to provide peripheral additional time to tri-state it's bus after a read operation. This is for all access types. |
| 12:13 | — | Reserved |
| 14:15 | DC4 | Deadcycles can be specified as 0 to 3. Dead cycles will be added to the end of Chip Select 4 read access and will occur in addition to any cycles which may already exist. These cycles are to provide peripheral additional time to tri-state it's bus after a read operation. This is for all access types. |
| 16:17 | — | Reserved |
| 18:19 | DC3 | Deadcycles can be specified as 0 to 3. Dead cycles will be added to the end of Chip Select 3 read access and will occur in addition to any cycles which may already exist. These cycles are to provide peripheral additional time to tri-state it's bus after a read operation. This is for all access types. |
| 20:21 | — | Reserved |
| 22:23 | DC2 | Deadcycles can be specified as 0 to 3. Dead cycles will be added to the end of Chip Select 2 read access and will occur in addition to any cycles which may already exist. These cycles are to provide peripheral additional time to tri-state it's bus after a read operation. This is for all access types. |
| 24:25 | — | Reserved |

**Table 9-12. Chip Select Deadcycle Control Register Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 26:27 | DC1 | Deadcycles can be specified as 0 to 3. Dead cycles will be added to the end of Chip Select 1 read access and will occur in addition to any cycles which may already exist. These cycles are to provide peripheral additional time to tri-state it's bus after a read operation. This is for all access types. |
| 28:29 | — | Reserved |
| 30:31 | DC0 | Deadcycles can be specified as 0 to 3. Dead cycles will be added to the end of Chip Select 0 read access and will occur in addition to any cycles which may already exist. These cycles are to provide peripheral additional time to tri-state it's bus after a read operation. This is for all access types. |

**NOTE**

Deadcycle counter is only used, if no arbitration to an other module (ATA or PCI) of the shared local bus happens. If an arbitration happens the bus can be driven within 4 IPB clocks by an other module.

## 9.7.2 SCLPC Registers

There are 6 32-bit BestComm Registers for the LocalPlus (SCLPC). These registers are located at an offset from MBAR of 0x3C00. Register addresses are relative to this offset. Therefore, the actual register address is: **MBAR + 0x3C00 + register address**

The following registers are available:

- SCLPC Packet Size Register (0x3C00)
- SCLPC Start Address Register (0x3C04)
- SCLPC Control Register (0x3C08)
- SCLPC Enable Register (0x3C0C)
- SCLPC Bytes Done Status Register (0x3C14)

### 9.7.2.1 SCLPC Packet Size Register

Address MBAR + 0x3C00

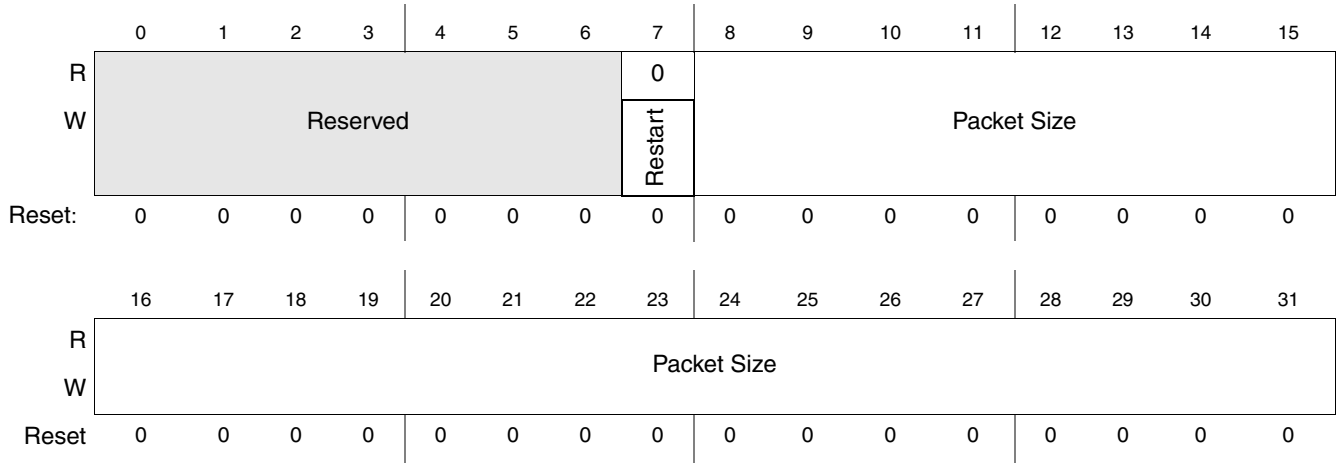



**Figure 9-13. SCLPC Packet Size Register**

**Table 9-13. SCLPC Packet Size Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7 | Restart | Once all registers have been programmed, software writes a 1 to this bit to begin a transfer. It will auto-clear and always reads back as zero. |
| 8:31 | Packet Size | This 24-bit field represents the number of bytes SCLPC is to transact before going idle and waiting for a Restart.<br>**Note:** The co-location of Restart bit and Packet_Size field allows Software to both Restart a transaction AND change the Packet_Size in a single write. Maximum packet size is 16M-1 bytes. |

### 9.7.2.2 SCLPC Start Address Register

Address MBAR + 0x3C04

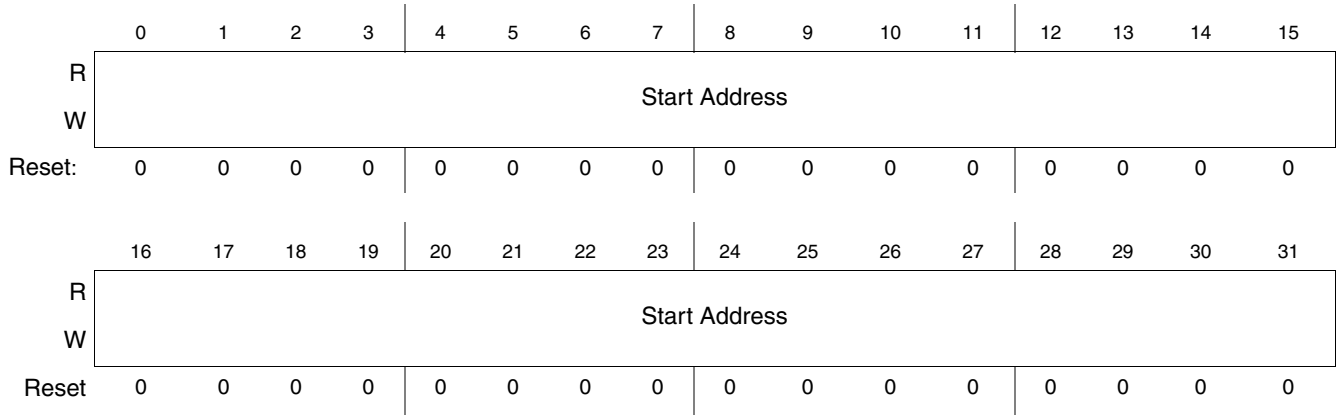



**Figure 9-14. SCLPC Start Address Register**

**Table 9-14. SCLPC Start Address Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Start Address | Address of the first byte in the packet to be sent. This value must be aligned with the BPT (Bytes Per Transaction) field, described below. This address will appear directly at the peripheral and is completely independent of XLB address decoding logic. |

### 9.7.2.3 SCLPC Control Register

Address MBAR + 0x3C08

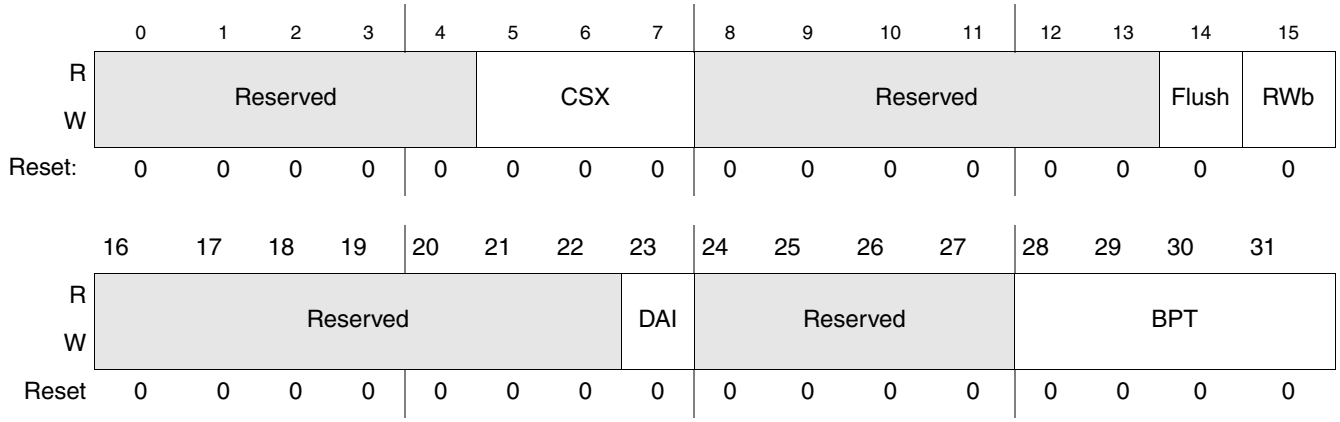



**Figure 9-15. SCLPC Control Register**

**Table 9-15. SCLPC Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:4 | — | Reserved |
| 5:7 | CSX | This field should be written with the Chip Select number associated with each DMA transaction.<br>**Note:** LPC configuration registers associated with this CS also affect SCLPC transactions. The two work together. |
| 8:13 | — | Reserved |
| 14 | Flush | If set to 1, enables the assertion of SCLPC requestor at the completion of a *Read* Packet, regardless of the actual state of the physical fifo ALarm. Requestor will de-assert once the fifo goes empty. This is the fix for the familiar Stale Read Data fifo problem. |
| 15 | RWb | Read - Write bar. Controls direction of DMA transaction.<br>1 = SCLPC will read from the peripheral, i.e. Fifo Receive<br>0 = SCLPC will write to the peripheral, i.e. Fifo Transmit |
| 16:22 | — | Reserved |
| 23 | DAI | Disable Auto Increment. Normally, SCLPC and LPC will present sequential incrementing addresses to the peripheral as the Packet proceeds. If the peripheral is operating as a single address Fifo, then the DAI bit should be set to 1. When set, addresses to the peripheral will be stuck at Start_Address for every transaction.<br>For DAI operation, the BPT field *MUST* be set to the port size of the peripheral. |
| 24:27 | — | Reserved |
| 28:31 | BPT | Bytes Per Transaction. Indicates number of bytes per transaction. The only valid entries in this field are decimal/hex 1, 2, 4, or 8 bytes (i.e. binary 0001, 0010, 0100, 1000). BPT should not be set to less than the peripheral port size, but certainly can be set to larger than the peripheral port size. The higher the BPT value, the greater the throughput.<br>**Note:** Start_Address and Packet_Size values *must* be aligned/multiples of BPT. For DAI operation, BPT must be set to the peripheral port size. |

### 9.7.2.4 SCLPC Enable Register

Address MBAR + 0x3C0C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | RC | Reserved | | | | | | | RF |
| Reset: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | AIE | NIE | Reserved | | | | | | | ME |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 9-16. SCLPC Enable Register**

**Table 9-16. SCLPC Enable Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7 | RC | Reset Controller. This bit allows for a Software reset of the SCLPC state machine. Writing a 1 to this bit will reset the SCLPC state machine. Reset will be maintained as long as this bit is high. Software must write this bit low to release the reset and start operation.<br>**Note:**<br>1. Although RC does *not* reset this register interface, it does clear interrupt and interrupt status conditions.<br>2. Never reset the SCLPC Controller during a transaction (tx or rx). |
| 8:14 | — | Reserved |
| 15 | RF | Reset Fifo. This is the Fifo software reset bit. Writing a 1 to this bit will reset the SCLPC Fifo. The Fifo must not be in reset for normal operation. Software reset of the Fifo will clear the fifo of data, reset its read/write pointers, but *not* disturb previously programmed Alarm and Granularity settings.<br>**Note:** Good Practice would be for software to set and clear the RC and RF bits prior to programming and starting a Packet. |
| 16:21 | — | Reserved |
| 22 | AIE | Abort Interrupt Enable. If set, and a fifo error occurs during packet transmission, a cpu interrupt from SCLPC will be generated. In any case, the Packet will be terminated and an Abort Status bit will be set.<br>**Note:** This bit does *not* affect the Requestor to BestComm in any way. |
| 23 | NIE | Normal Interrupt Enable. This bit, if set enables a cpu interrupt to occur at the end of a normally terminated Packet. There is also a NT status bit which sets in any case.<br>**Note:** This bit does *not* affect the Requestor to BestComm in any way. |
| 24:30 | — | Reserved |
| 31 | ME | Master Enable. This bit must be set to 1 to allow a Restart to be generated to the SCLPC state machine. Restart is achieved by writing 1 to Byte 0 of the Packet_Size register. This ME bit must also be set for a Restart to occur.<br>**Note:** ME being low (inactive) will also clear Interrupt and Interrupt status. But it does *NOT* affect the BestComm Requestor. |

### 9.7.2.5 SCLPC Bytes Done Status Register

Address MBAR + 0x3C14

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | AT | Reserved | | | NT | Bytes Done | | | | | | | |
| W | | | | rwc | | | | rwc | Read Only | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | X | X | X | X | X | X | X | X |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Bytes Done | | | | | | | | | | | | | | | |
| W | Read Only | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

**Note:** X: Bit does not reset to a defined value.

**Figure 9-17. SCLPC Bytes Done Status Register**

**Table 9-17. SCLPC Bytes Done Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:2 | — | Reserved |
| 3 | AT | Abort Termination. This bit will be set to 1 if the Packet has terminated abnormally (which is only possible if a fifoError occurred).<br>**Note:** This bit is ANDed with the AIE bit above to generate a single CPU interrupt signal to the core. This bit is sticky write to 1" for clearing the bit and clearing the interrupt.<br>**Note:** This bit (and any interrupt) is also cleared if; 1) RC bit is set, 2) ME bit is clear, or 3) Restart occurs. |
| 4:6 | — | Reserved |
| 7 | NT | Normal Termination. This bit is set to 1 whenever a complete Packet has been transferred successfully.<br>**Note:** This bit is ANDed with the NIE bit above to generate a single CPU interrupt signal to the core. This bit is sticky write to 1 for clearing the bit and clearing the interrupt. |
| 8:31 | Bytes Done | Bytes Done is updated dynamically by the SCLPC state machine to represent the actual number of bytes transmitted at a given point in time. At the normal conclusion of a Packet, the bytes_done field should match the Packet_Size field. |

## 9.7.3 SCLPC FIFO Registers

LPC uses a single FIFO that changes direction based on the Rx/Tx mode. Software controls direction change and flushes FIFO before changing directions. FIFO memory is 512 Bytes (32 x 128).

LPC FIFO is controlled by six 32-bit registers. These registers are located at an offset from MBAR of 0x3C40. Register addresses are relative to this offset. Therefore, the actual register address is: **MBAR + 0x3C40 + register address**

Hyperlinks to the LPC FIFO registers are provided below:

- LPC Rx/Tx FIFO Data Word Register (0x3C40)
- LPC Rx/Tx FIFO Status Register (0x3C44)
- LPC Rx/Tx FIFO Control Register (0x3C48)
- LPC Rx/Tx FIFO Alarm Register (0x3C4C)
- LPC Rx/Tx FIFO Read Pointer Register (0x3C50)
- LPC Rx/Tx FIFO Write Pointer Register (0x3C54)

### 9.7.3.1 LPC Rx/Tx FIFO Data Word Register LPC_rx/tx_fifo_data_word_register

Address MBAR + 0x3C14

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | FIFO_Data_Word | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | FIFO_Data_Word | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

**Note:** X: Bit does not reset to a defined value.

**Figure 9-18. LPC Rx/Tx FIFO Data Word Register**

**Table 9-18. LPC Rx/Tx FIFO Data Word Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | FIFO_Data_Word | The FIFO data port. Reading from this location “pops” data from the FIFO, writing “pushes” data into the FIFO. During normal operation the BestComm Controller pushes data here.<br>**Note:** ONLY full word access is allowed. If all byte enables are not asserted when accessing this location, a FIFO error flag is generated. |

### 9.7.3.2 LPC Rx/Tx FIFO Status Register

Address MBAR + 0x3C44

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | Err | UF | OF | Full | HI | LO | Emty |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 9-19. LPC Rx/Tx FIFO Status Register**

**Table 9-20. LPC Rx/Tx FIFO Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:8 | — | Reserved |
| 9 | Err | Error—flag bit is essentially the logical OR of other flag bits and can be polled for detection of any FIFO error. After clearing the offending condition, writing 1 to this bit clears flag. |
| 10 | UF | UnderFlow—flag indicates read pointer has surpassed the write pointer. FIFO was read beyond empty. Resetting FIFO clears this condition; writing 1 to this bit clears flag. |
| 11 | OF | OverFlow—flag indicates write pointer surpassed read pointer. FIFO was written beyond full. Resetting FIFO clears this condition; writing 1 to this bit clears flag. |
| 12 | Full | FIFO full—this is NOT a sticky bit or error condition. Full indication tracks with FIFO state. |
| 13 | HI | High—FIFO requests attention, because high level alarm is asserted. To clear this condition, FIFO must be read to a level below the setting in granularity bits. |
| 14 | LO | Low—FIFO requests attention, because Low level alarm is asserted. To clear this condition, FIFO must be written to a level in which the space remaining is less than the granularity bit setting. |
| 15 | Emty | FIFO empty—this is NOT a sticky bit or error condition. Full indication tracks with FIFO state. |
| 16:31 | — | Reserved |

### 9.7.3.3 LPC Rx/Tx FIFO Control Register

Address MBAR + 0x3C48

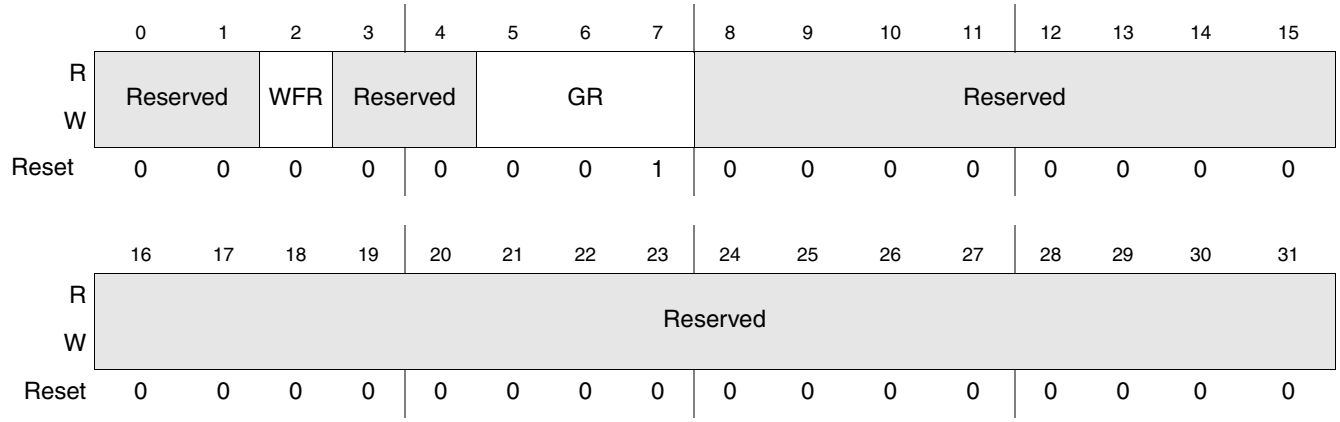



**Table 9-21. LPC Rx/Tx FIFO Control Register**

**Table 9-22. LPC Rx/Tx FIFO Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2 | WFR | When bit sets, FIFO Controller assumes next data write is End of Frame (EOF).<br>**Note:** This module does not support Framing. This bit should remain low. |
| 3:4 | — | Reserved |
| 5:7 | GR | Granularity—bits control high “watermark” point at which FIFO negates Alarm condition (i.e., request for data). It represents the number of free bytes times 4.<br>000 = FIFO waits to become completely full before stopping data request.<br>001 = FIFO stops data request when only one long word of space remains. |
| 8:31 | — | Reserved |

### 9.7.3.4 LPC Rx/Tx FIFO Alarm Register

Address MBAR + 0x3C4C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | Alarm | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 9-23. LPC Rx/Tx FIFO Alarm Register**

**Table 9-24. LPC Rx/Tx FIFO Alarm Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:22 | — | Reserved |
| 23:31 | Alarm | User writes these bits to set low level “watermark”, which is the point where FIFO asserts request for BestComm Controller data filling. Value is in bytes. For example, with Alarm = 32, alarm condition occurs when FIFO contains 32 Bytes or less. Once asserted, alarm does not negate until high level mark is reached, as specified by FIFO control register granularity bits. |

### 9.7.3.5 LPC Rx/Tx FIFO Read Pointer Register

Address MBAR + 0x3C50

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | ReadPtr | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 9-25. LPC Rx/Tx FIFO Read Pointer Register**

**Table 9-26. LPC Rx/Tx FIFO Read Pointer Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:22 | — | Reserved |
| 23:31 | ReadPtr | Value is maintained by FIFO hardware and is NOT normally written. It can be adjusted in special cases, but this disrupts data flow integrity. Value represents the Read address presented to the FIFO RAM. |

### 9.7.3.6 LPC Rx/Tx FIFO Write Pointer Register

Address MBAR + 0x3C54

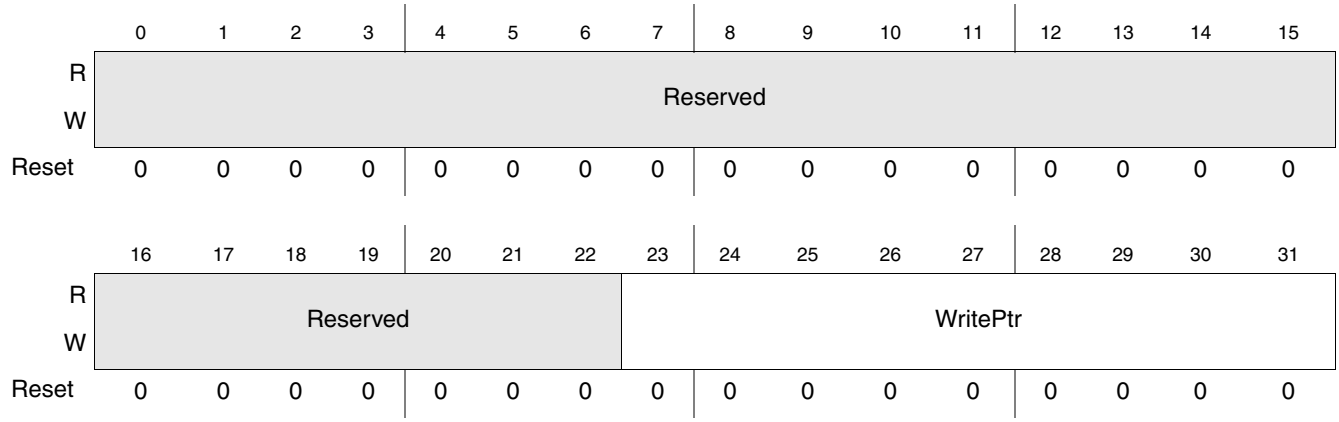



**Table 9-27. LPC Rx/Tx FIFO Write Pointer Register**

**Table 9-28. LPC Rx/Tx FIFO Write Pointer Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:22 | — | Reserved |
| 23:31 | WritePtr | Value is maintained by FIFO hardware and is NOT normally written. It can be adjusted in special cases, but this disrupts data flow integrity. Value represents the Read address presented to the FIFO RAM. |

# Chapter 10
# PCI Controller

## 10.1 Overview

The Peripheral Component Interface (PCI) Bus is a high-performance bus with multiplexed address and data lines. It is especially suitable for high data-rate applications.

The MPC5200B PCI Controller module supports a 32-bit PCI initiator and target interface. As a target, access to the internal XL bus is supported. As an initiator, the PCI controller is coupled directly to the XL bus (as a slave) and available on the Communication Sub-System as a Multi-Channel DMA peripheral.

The 32-bit multiplexed address/data is shared with the ATA Controller and LocalPlus Controllers. However, control signals are on separate pins and only one operation (PCI, ATA, or LocalPlus) can be done at any given time.

The LocalPlus Large Flash and Most/Graphic interfaces are not compatible with any PCI operation. When these interfaces are needed, the PCI internal controller **must** be disabled by setting bit 16 (PCI_DIS) of the GPS Configuration register. See Section 7.3.2.1.1, "GPS Port Configuration Register."

The MPC5200B contains PCI central resource functions such as the PCI Arbiter (see Section 10.5, "PCI Arbiter") and PCI reset control. The PCI bus clock is ***always*** sourced from the MPC5200B and either equal to 1, 1/2 the frequency of the Slave bus clock (IP bus clock) or 1/4 the frequency of the XL Bus clock. Even when the PCI internal controller is disabled, the PCI clock is sourced by the MPC5200B.

A PCI reset signal is provided and implemented as an open-drain pin. An external (on board) pull-up resistor (e.g. 5.6 kOhm) is then required to ensure proper operation.

**NOTE**

If the PCI interface is NOT used (and internally disabled) the PCI control pins must be terminated as indicated by the PCI Local Bus specification. PCI control signals always require pull-up resistors to ensure that they contain stable values when no agent is actively driving the bus. This includes PCI_FRAME, PCI_TRDY, PCI_IRDY, PCI_DEVSEL, PCI_STOP, PCI_SERR, PCI_PERR, and PCI_REQ.

### 10.1.1 Features

- Supports system clock: Slave (IP) bus (internal peripheral slave bus) to PCI bus frequency ratios 1:1, 2:1. Or the XL Bus to PCI bus frequency ratio 4:1 (e.g. PCI runs at 33 MHz while the XL Bus bus runs at 132 MHz).
- Compatible with PCI 2.2 specification
- PCI initiator and target operation
- Fully synchronous design
- 32-bit PCI Address/Data bus
- PCI 2.2 Type 0 Configuration Space header
- Supports the PCI 16/8 clock rule
- PCI master Multi-Channel DMA or CPU access to PCI Bus
- High transfer rates at 66Mhz PCI clock, 512 byte buffer
- PCI to system bus address translation
- Target response is medium $\overline{\text{DEVSEL}}$ generation
- Initiator latency time-outs are **NOT** supported.
- Automatic retry of target disconnects
- Fast Back-to-Back transactions are **NOT** supported.

**NOTE**

The corresponding FC bit in the Configuration Status Register is fixed to ‘1’ indicating the opposite. Nonetheless no Fast Back-to-Back transaction is supported.

## 10.1.2 Block Diagram

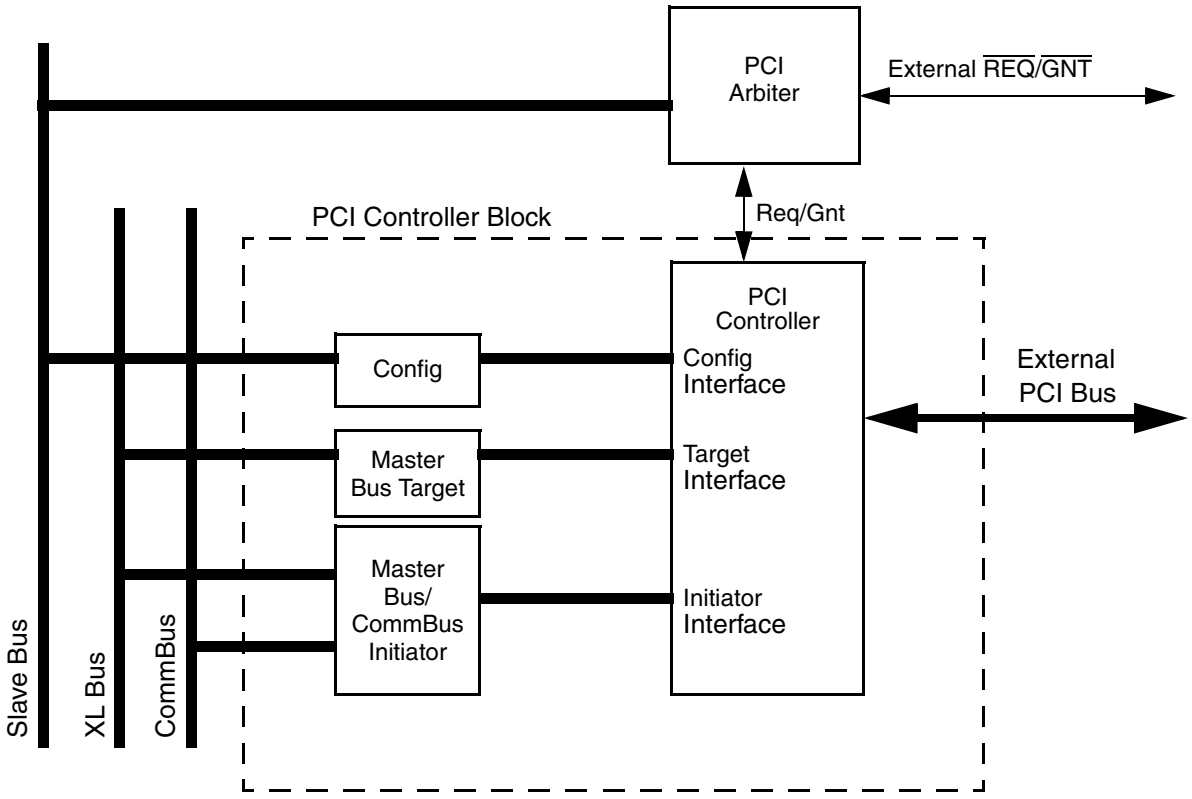



**Figure 10-1. PCI Block Diagram**

## 10.2 PCI External Signals

**Table 10-1. PCI External Signals**

| Signal | I/O | Definition |
|---|---|---|
| AD[31:0] | I/O | Multiplexed Address and Data Bus (Shared with ATA and LPC). AD31 is the most significant bit while AD0 is the least significant as per the PCI specification. The entire PCI external bus is little Endian ordered. |
| PCI_CBE[3:0] | I/O | Command/Bytes Enables |
| PCI_DEVSEL | I/O | Device Select |
| PCI_FRAME | I/O | Frame |
| PCI_IDSEL | I | Initialization Device Select |
| PCI_IRDY | I/O | Initiator Ready |
| PCI_PAR | I/O | Parity |
| PCI_CLK | O | PCI Clock |
| PCI_PERR | I/O | Parity Error |
| PCI_RST | O | PCI Reset |
| PCI_SERR | I/O | System Error |
| PCI_STOP | I/O | Stop |
| PCI_TRDY | I/O | Target Ready |

For detailed description of the PCI bus signals, see the *PCI Local Bus Specification, Revision 2.2*.

### 10.2.1 PCI_AD[31:0] — Address/Data Bus

The PCI_AD[31:0] lines are a time multiplexed address data bus. The address is presented on the bus during the address phase while the data is presented on the bus during one or more data phases.

### 10.2.2 $\overline{\text{PCI\_CBE[3:0]}}$ — Command/Byte Enables

The $\overline{\text{PCI\_CBE[3:0]}}$ lines are time multiplexed. The PCI command is presented during the address phase and the byte enables are presented during the data phase.

### 10.2.3 $\overline{\text{PCI\_DEVSEL}}$ — Device Select

The $\overline{\text{PCI\_DEVSEL}}$ signal is asserted active low when MPC5200B decodes that it is the target of a PCI transaction from the address presented on the PCI bus during the address phase.

### 10.2.4 $\overline{\text{PCI\_FRAME}}$ — Frame

The $\overline{\text{PCI\_FRAME}}$ signal is asserted by a PCI initiator to indicate the beginning of a transaction. It is deasserted when the initiator is ready to complete the final data phase.

### 10.2.5 PCI_IDSEL — Initialization Device Select

The PCI_IDSEL signal is asserted during a PCI Type 0 Configuration Cycle to address the PCI Configuration header.

### 10.2.6 $\overline{\text{PCI\_IRDY}}$ — Initiator Ready

The $\overline{\text{PCI\_IRDY}}$ signal is asserted to indicate that the PCI initiator is ready to transfer data. During a write operation, assertion indicates that the master is driving valid data on the bus. During a read operation, assertion indicates that the master is ready to accept data.

#### 10.2.6.1 PCI_PAR — Parity

The PCI_PAR signal indicates the parity of data on the PCI_AD[31:0] and $\overline{\text{PCI\_CBE}}$[3:0] lines.

### 10.2.7 PCI_CLK — PCI Clock

The PCI_CLK signal is the clock for the internal PCI Controller and the external PCI system. The PCI clock is also used as reference clock for the LocalPlus synchronous interfaces (Burst Flash, ATA). The PCI_CLK is **always** sourced by the MPC5200B.

### 10.2.8 $\overline{\text{PCI\_PERR}}$ — Parity Error

The $\overline{\text{PCI\_PERR}}$ signal, if enabled, is asserted when a data phase parity error is detected.

### 10.2.9 $\overline{\text{PCI\_RST}}$ — Reset

The $\overline{\text{PCI\_RST}}$ signal is asserted active low by MPC5200B to reset the PCI bus. This signal is asserted after MPC5200B reset and must be negated to enable usage of the PCI bus. An external shared pull-up resistor is required on this pin.

### 10.2.10 $\overline{\text{PCI\_SERR}}$ — System Error

The $\overline{\text{PCI\_SERR}}$ signal, if enabled, is asserted by the MPC5200B *only* when an address phase parity error is detected.

### 10.2.11 $\overline{\text{PCI\_STOP}}$ — Stop

The $\overline{\text{PCI\_STOP}}$ signal is asserted by the currently addressed target to indicate that it wishes to stop the current transaction.

### 10.2.12 $\overline{\text{PCI\_TRDY}}$ — Target Ready

The $\overline{\text{PCI\_TRDY}}$ signal is asserted by the currently addressed target to indicate that it is ready to complete the current data phase.

## 10.3 Registers

MPC5200B has several sets of registers that control and report status for the different interfaces to the PCI controller: PCI Type 0 Configuration Space Registers, General Status/Control Registers, and Communication Sub-System Interface Registers. All of these registers are accessible as offsets of MBAR (the PCI interface is located starting at offset 0x0D00 relative to the MBAR register's value, while the BestComm interface starts at offset 0x3800). As an XL bus master, an external PCI bus master can access MBAR space for register updates and the internal SRAM.

**NOTE**

$\overline{\text{PCI\_RST}}$ is controlled by a bit in the register space and must first be cleared before external PCI devices wake-up. In other words, an external PCI master cannot load configuration software across the PCI bus until this bit is cleared by internal means.

All registers are accessible at an offset of MBAR in the memory space. There are two module offsets for PCI configuration space. One is allocated to the Communication Sub-System Interface registers and the other to all other PCI Controller Registers including the standard Type 0 PCI Configuration Space. Software reads from unimplemented registers return 0x00000000 and writes have no effect. See Section 3.2, "Internal Register Memory Map" for module offsets and descriptions of module responses.

**Table 10-2. PCI Register Map**

| Register Offset | Mnemonic | Name |
|---|---|---|
| **PCI Type 0 Configuration Registers** | | |
| 0x00 | PCIIDR | Device ID/Vendor ID |
| 0x04 | PCISCR | Status/Command |
| 0x08 | PCICCRIR | Class Code/Revision ID |
| 0x0C | PCICR1 | Configuration 1Register |
| 0x10 | PCIBAR0 | Base Address Register 0 |
| 0x14 | PCIBAR1 | Base Address Register 1 |
| 0x18 | Reserved | |
| ... | | |
| 0x24 | | |
| 0x28 | PCICCPR | Cardbus CIS Pointer |
| 0x2C | PCISID | Subsystem ID/Subsystem Vendor ID |
| 0x30 | PCIERBAR | Expansion ROM |
| 0x34 | PCICPR | Capabilities Pointer |
| 0x38 | Reserved | |
| 0x3C | PCICR2 | Configuration 2 Register |
| 0x40 | Reserved | |
| ... | | |
| 0x5C | | |

**Table 10-2. PCI Register Map (continued)**

| Register Offset | Mnemonic | Name |
|---|---|---|
| **General Control/Status Registers** | | |
| 0x60 | PCIGSCR | Global Status/Control Register |
| 0x64 | PCITBATR0 | Target Base Address Translation Register 0 |
| 0x68 | PCITBATR1 | Target Base Address Translation Register 1 |
| 0x6C | PCITCR | Target Control Register |
| 0x70 | PCIIW0BTAR | Initiator Window 0 Base/Translation Address Register |
| 0x74 | PCIIW1BTAR | Initiator Window 1 Base/Translation Address Register |
| 0x78 | PCIIW2BTAR | Initiator Window 2 Base/Translation Address Register |
| 0x7C | Reserved | |
| 0x80 | PCIIWCR | Initiator Window Configuration Register |
| 0x84 | PCIICR | Initiator Control Register |
| 0x88 | PCIISR | Initiator Status Register |
| 0x8C | PCIARB | PCI Arbiter Register |
| 0x90 | Reserved | |
| ... | | |
| 0xF4 | | |
| 0xF8 | PCICAR | Configuration Address Register |
| 0xFC | Reserved | |

**Table 10-3. PCI Communication System Interface Register Map**

| Register Offset | Mnemonic | Name |
|---|---|---|
| 0x00 | PCITPSR | Tx Packet Size |
| 0x04 | PCITSAR | Tx Start Address |
| 0x08 | PCITTCR | Tx Transaction Control Register |
| 0x0C | PCITER | Tx Enables |
| 0x10 | PCITNAR | Tx Next Address |
| 0x14 | PCITLWR | Tx Last Word |
| 0x18 | PCITDCR | Tx Bytes Done Counts |
| 0x1C | PCITSR | Tx Status |
| 0x20 | PCITPDCR | Tx Packets Done Counts |
| 0x24 | Reserved | |
| ... | | |
| 0x3C | | |
| 0x40 | PCITFDR | Tx FIFO Data |

**Table 10-3. PCI Communication System Interface Register Map (continued)**

| Register Offset | Mnemonic | Name |
|---|---|---|
| 0x44 | PCITFSR | Tx FIFO Status |
| 0x48 | PCITFCR | Tx FIFO Control |
| 0x4C | PCITFAR | Tx FIFO Alarm |
| 0x50 | PCITFRPR | Tx FIFO Read Pointer |
| 0x54 | PCITFWPR | Tx FIFO Write Pointer |
| 0x58 | Reserved | |
| ... | | |
| 0x7C | | |
| 0x80 | PCIRPSR | Rx Packet Size |
| 0x84 | PCIRSAR | Rx Start Address |
| 0x88 | PCIRTCR | Rx Transaction Control Register |
| 0x8C | PCIRER | Rx Enables |
| 0x90 | PCIRNAR | Rx Next Address |
| 0x94 | PCIRLWR | Rx Last Word |
| 0x98 | PCIRDCR | Rx Bytes Done Counts |
| 0x9C | PCIRSR | Rx Status |
| 0xA0 | PCIRPDCR | Rx Packets Done Counts |
| 0xA4 | Reserved | |
| ... | | |
| 0xBC | | |
| 0xC0 | PCIRFDR | Rx FIFO Data |
| 0xC4 | PCIRFSR | Rx FIFO Status |
| 0xC8 | PCIRFCR | Rx FIFO Control |
| 0xCC | PCIRFAR | Rx FIFO Alarm |
| 0xD0 | PCIRFRPR | Rx FIFO Read Pointer |
| 0xD4 | PCIRFWPR | Rx FIFO Write Pointer |
| 0xD8 | Reserved | |
| ... | | |
| 0xFC | | |

### 10.3.1 PCI Controller Type 0 Configuration Space

MPC5200B supplies a type 0 PCI Configuration Space header. These registers are accessible as an offset from MBAR (Section 3.2, “Internal Register Memory Map”) or through externally mastered PCI Configuration Cycles.

**NOTE**

The internal PCI controller can discover itself (by means of connecting an AD line [preferably AD24 to AD31]to the PCI _IDSEL input). It is essential, when the PCI interface is used as a Target, to enable the internal PCI controller to access via the external PCI bus its own PCI registers. This is the only available way in order to clear any error flag RWC bit (Read/Write/Clear bit).

| Reg Addr | PCI DWord Offset | Reg | [31:24] | [23:16] | [15:8] | [7:0] |
|---|---|---|---|---|---|---|
| 0x100 | 0x00 | PCIIDR | Device ID | | Vendor ID | |
| 0x104 | 0x01 | PCISCR | Status | | Command | |
| 0x108 | 0x02 | PCICCRIR | Class Code | | | Revision ID |
| 0x10C | 0x03 | PCICR1 | BIST | Header Type | Latency Timer | Cache Line Size |
| 0x110 | 0x04 | PCIBAR0 | BAR0 | | | |
| 0x114 | 0x05 | PCIBAR0 | BAR1 | | | |
| 0x118 | 0x06 | | Reserved | | | |
| ... | ... | | | | | |
| 0x124 | 0x09 | | | | | |
| 0x128 | 0x0A | PCICCPR | CardBus CIS Pointer | | | |
| 0x12C | 0x0B | PCISID | Subsystem ID | | Subsystem Vendor ID | |
| 0x130 | 0x0C | | Expansion ROM Base Address | | | |
| 0x134 | 0x0D | | Reserved | | | Cap_Ptr |
| 0x138 | 0x0E | | Reserved | | | |
| 0x13C | 0x0F | PCICR2 | Min_Gnt | Max_Lat | Int Pin | Int Line |
| na | 0x10 | | Reserved | | | |
| na | ... | | | | | |
| na | 0x3F | | | | | |

PCI Dword Reserved space (0x10–0x3F) can be accessed only from an external PCI Configuration access.

**NOTE**

A PCI Double Word (DWORD) is a 32 bit long word. A PowerPC Double Word is instead a 64 bit word (according to the EABI rule) while a Word is a 32 bit value. In the following PCI Configuration space a DWORD refers **always** to a 32 bit word.

### 10.3.1.1 Device ID/ Vendor ID Registers PCIIDR(R)

MBAR + 0x0D00

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Device ID | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0x5809 | | | | | | | | | | | | | | | |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Vendor ID | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0x1057 | | | | | | | | | | | | | | | |

**Figure 10-2. Device ID/Vendor ID Registers PCIIDR(R)**

**Table 10-4. Device ID/Vendor ID Registers PCIIDR(R) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:15 | Device ID | This field is read-only and represents the PCI Device Id assigned to MPC5200B<br>Its value is: 0x5809. |
| 16:31 | Vendor ID | This field is read-only and represents the PCI Vendor Id assigned to MPC5200B<br>Its value is: 0x1057. |

### 10.3.1.2 Status/Command Registers PCISCR(R/RW/RWC)

MBAR + 0x0D04

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | PE | SE | MA | TR | TS | DT | | DP | FC | R | 66M | C | Reserved | | | |
| W | rwc | rwc | rwc | rwc | rwc | | | rwc | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | F | S | St | PER | V | MW | Sp | B | M | IO |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-3. Status/Command Registers PCISCR(R/RW/RWC)**

Bits 31-27 and 24 are read-write-clear (RWC).

- Hardware can set RWC bits, but cannot clear them.
- Only PCI configuration cycles can clear RWC bits that are currently set by writing a 1 to the bit location. Writing a 1 to a RWC bit that is currently a 0 or writing a 0 to any RWC bit has no effect.

**Table 10-5. Status/Command Registers PCISCR (R/RW/RWC) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | Parity Error Detected (PE) | This bit is set when a parity error is detected, even if the Parity Error Response bit in the Command Register (bit 6) is disabled. A CPU interrupt will be generated if the PCIGSCR[PEE] bit is set. This register is read-write-clear (RWC) via PCI configuration cycles. |
| 1 | System Error Signalled (SE) | This bit is set whenever MPC5200B generates a PCI System Error on the $\overline{\text{SERR}}$ line. This register is read-write-clear (RWC) via PCI configuration cycles. |
| 2 | Master Abort Received (MA) | This bit is set whenever MPC5200B is the PCI master and terminates a transaction (except for Special Cycle) with a Master-Abort. This register is read-write-clear (RWC) via PCI configuration cycles. |
| 3 | Target Abort Received (TR) | This bit is set whenever MPC5200B is the PCI master and a transaction is terminated by a Target Abort from the currently-addressed target. This register is read-write-clear (RWC) via PCI configuration cycles. |
| 4 | Target Abort Signalled (TS) | This bit is set whenever MPC5200B is the PCI target and it terminates a transaction with a Target Abort. This register is read-write-clear (RWC) via PCI configuration cycles. |
| 5:6 | DEVSEL# Timing (DT) | Fixed to 01. These bits encode a medium $\overline{\text{DEVSEL}}$ timing. This defines the slowest $\overline{\text{DEVSEL}}$ timing when MPC5200B is the PCI target (except configuration accesses). |
| 7 | Master Data Parity Error (DP) | This bit applies only when MPC5200B is PCI master and is set only if the following conditions are met:<br>• MPC5200B-as-master sets $\overline{\text{PERR}}$ itself during a read or detected it asserted by the target during a write<br>• The Parity Error Response bit in the Command Register, bit 6, is set to 1<br>This register is read-write-clear (RWC) via PCI configuration cycles. |
| 8 | Fast Back-to-Back Capable (FC) | Fixed to 1. The MPC5200B PCI controller does **NOT** support Fast Back-to-Back transactions. |
| 9 | Reserved (R) | Fixed to 0. Prior to the 2.2 PCI Spec, this was the UDF (User Defined Features) Supported bit.<br>1 = Supported User Defined Features<br>0 = Does not support UDF |
| 10 | 66 MHz Capable (66M) | Fixed to 1. This bit indicates that the PCI controller is 66 MHz capable. |
| 11 | Capabilities List (C) | Fixed to 0. This bit indicates that the PCI controller does not implement the New Capabilities List Pointer Configuration Register in DWORD 13 of the Configuration Space. |
| 12:21 | Reserved | These bits are reserved. |
| 22 | Fast Back-to-Back Transfer Enable (F) | The MPC5200B PCI controller does **NOT** support Fast Back-to-Back transactions.<br>Setting this bit has no effect. |
| 23 | $\overline{\text{SERR}}$ enable (S) | This bit is an enable bit for the $\overline{\text{SERR}}$ driver. A value of zero disables the $\overline{\text{SERR}}$ driver. A value of 1 enables the $\overline{\text{SERR}}$ driver. Note: Address parity errors are reported only if this bit and bit 6 are 1. This bit is programmable (read/write from both the IP bus and PCI bus Configuration cycles). |

**Table 10-5. Status/Command Registers PCISCR (R/RW/RWC) Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 24 | Address and Data Stepping (St) | Fixed to 0. This bit indicates that the PCI controller never uses address/data stepping. Initialization software should write a 0 to this bit location. |
| 25 | Parity Error Response (PER) | This bit controls the device's response to parity errors. When set and a parity error is detected, the PCI controller asserts $\overline{\text{PERR}}$. When the bit is "0", the device sets its Detected Parity Error status bit (bit 0) in the event of a parity error, but does not assert $\overline{\text{PERR}}$.<br>This bit is programmable (read/write from both the IP bus and PCI bus Configuration cycles). |
| 26 | VGA Palette Snoop Enable (V) | Fixed to 0. This bit indicates that the PCI controller is not VGA compatible. Initialization software should write a 0 to this bit location. |
| 27 | Memory Write and Invalidate Enable (MW) | This bit is an enable for using the Memory Write and Invalidate command. When this bit is 1, MPC5200B-as-master may generate the command. When it is 0, Memory Write must be used instead. This bit is programmable (read/write from both the IP bus and PCI bus Configuration cycles). |
| 28 | Special Cycle Monitor or Ignore (Sp) | This bit is to determine whether or not to ignore PCI Special Cycles. Since MPC5200B-as-target does not recognize messages delivered via the Special Cycle operation, a value of 1 should never be programmed to this register. This bit, however, is programmable (read/write from both the IP bus and PCI bus Configuration cycles). |
| 29 | Bus Master Enable (B) | This bit indicates whether or not MPC5200B has the ability to serve as a master on the PCI bus. A value of 1 indicates this ability is enabled. If MPC5200B is used as a master on the PCI bus (via XL bus or CommBus), a 1 should be written to this bit during initialization. Even if set to 0, a transaction initiated by an internal master (the core, BestComm) is allowed to take place. It is meant to be read by configuration software.<br>This bit is programmable (read/write from both the IP bus and PCI bus Configuration cycles). |
| 30 | Memory Access Control (M) | This bit controls the PCI controller's response to Memory Space accesses. A value of 0 disables the response. A value of 1 allows the controller to recognize a Memory access.<br>This bit is programmable (read/write from both the IP bus and PCI bus Configuration cycles). |
| 31 | IO access Control (IO) | Fixed to 0. This bit is not implemented because there is no MPC5200B IO type space accessible from the PCI bus. The PCI base address registers are Memory address ranges only. Initialization software should write a 0 to this bit location. |

### 10.3.1.3 Revision ID/ Class Code Registers PCICCRIR(R)

MBAR + 0x0D08

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Class Code | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0x0680 | | | | | | | | | | | | | | | |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Class Code (continued) | | | | | | | | Revision ID | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0x00 | | | | | | | | 0x00 | | | | | | | |

**Figure 10-4. Revision ID/ Class Code Registers PCICCRIR(R)**

**Table 10-6. Revision ID/ Class Code Registers PCICCRIR(R) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:23 | Class Code | This field is read-only and represents the PCI Class Code assigned to MPC5200B<br>Its value is: 0x068000. (Other bridge device) |
| 24:31 | Revision ID | This field is read-only and represents the PCI Revision Id for this version of MPC5200B. Its value is: 0x00. |

### 10.3.1.4 Configuration 1 Register PCICR1(R/RW)

MBAR + 0x0D0C

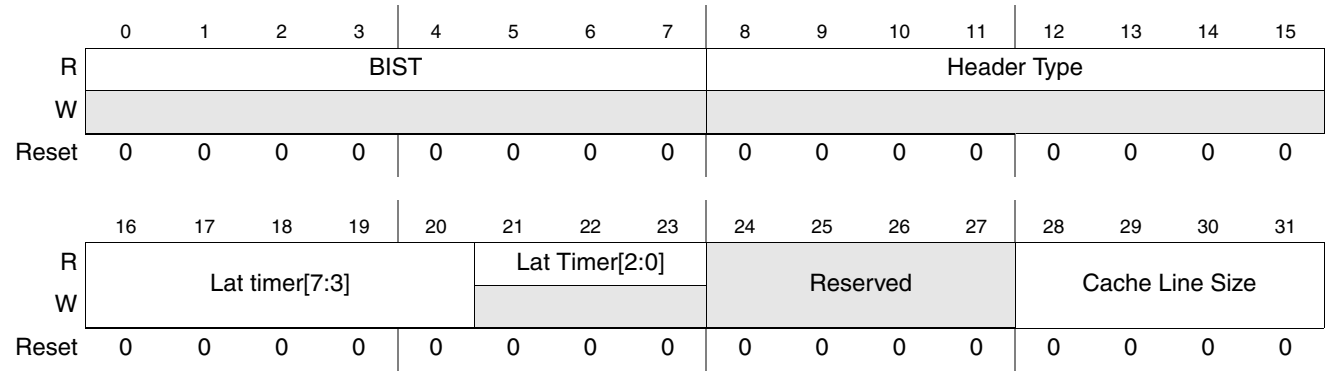



**Figure 10-5. Configuration 1 Register PCICR1(R/RW)**

**Table 10-7. Configuration 1 Register PCICR1(R/RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | Built-In Self Test (BIST) | Fixed to 0x00. The PCI controller does not implement the Built-In Self Test register. Initialization software should write a 0x00 to this register location. |
| 8:15 | Header Type | Fixed to 0x00. The PCI controller implements a Type 0 PCI Configuration Space Header. Initialization software should write a 0x00 to this register location. |
| 16:23 | Latency Timer | This register contains the latency timer value, in PCI clocks, used when MPC5200B is the PCI master. The lower three bits of the register are hardwired low and the upper five bits are programmable (read/write from both the IP bus and PCI bus Configuration cycles).<br>**Note:** The MPC5200B does NOT support initiator latency time-outs, the internal PCI Arbiter does not support preemption of the internal masters XIPCI or SCPCI. The internal master is granted until the transaction has been completed. The Latency Timer (LT) cannot terminate any transfer. |
| 28:31 | Cache Line Size | The four lower bits of this register are programmable (read/write from both the IP bus and PCI bus Configuration cycles). The value programmed specifies the cacheline size in units of DWORDs. |

### 10.3.1.5 Base Address Register 0 PCIBAR0(RW)

MBAR + 0x0D10

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Base Address 0 | | | | | | | | | | | | | | Reserved | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | pref | range | | IO/M # |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-6. Base Address Register 0 PCIBAR0(RW)**

**Table 10-8. Base Address Register 0 PCIBAR0(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:13 | Base Address Register 0 (BAR0) | MPC5200B PCI Base Address Register 0 (256Kbyte). Applies only when MPC5200B is target. These bits are programmable (read/write from both the IP bus and PCI bus Configuration cycles). This BAR register *should* be used to point at the internal MPC5200B register space (MBAR) |
| 14:27 | Reserved | These bits are reserved. |
| 28 | prefetchable access (pref) | Fixed to 0. This bit indicates that the memory space defined by BAR0 is NOT prefetchable. Configuration software should write a 0 to this bit location. |
| 29:30 | range | Fixed to 00. This register indicates that base address 0 is 32 bits wide and can be mapped anywhere in 32-bit address space. Configuration software should write 00 to these bit locations. |
| 31 | IO or Memory Space (IO/M#) | Fixed to 0. This bit indicates that BAR0 is for memory space. Configuration software should write a 0 to this bit location.<br>0 = Memory<br>1 = I/O |

### 10.3.1.6 Base Address Register 1 PCIBAR1(RW)

MBAR + 0x0D14

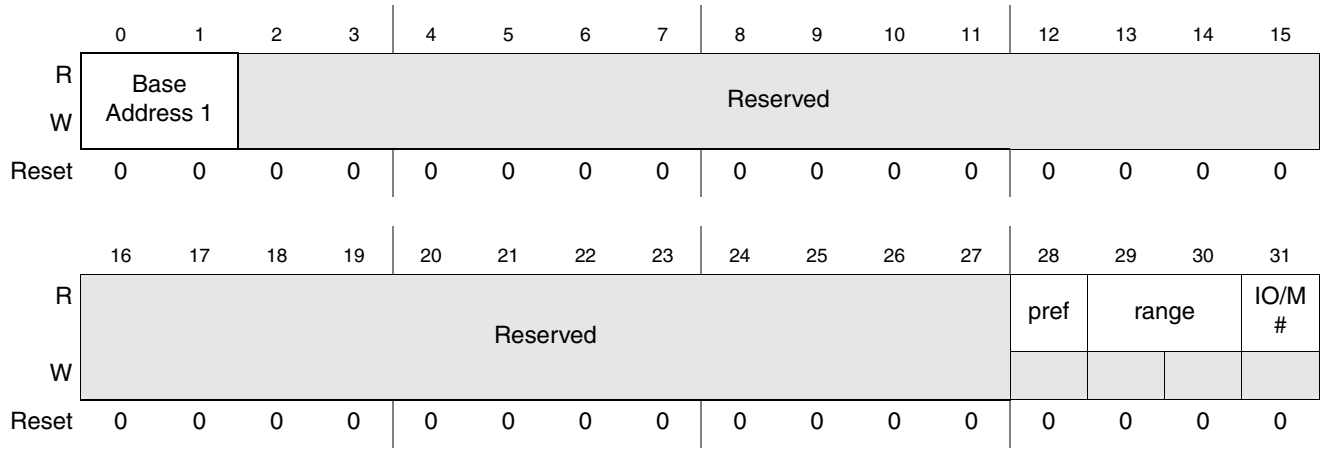



**Figure 10-7. Base Address Register 1 PCIBAR1(RW)**

**Table 10-9. Base Address Register 1 PCIBAR1(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:1 | Base Address Register 1 (BAR1) | MPC5200B PCI Base Address Register 1 (1Gbyte). Applies only when MPC5200B is target. These bits are programmable (read/write from both the IP bus and PCI bus Configuration cycles). This BAR register shall be used to point at the local SDRAM/DDR Memory Space.<br>**Note:** The address 'Window' is much larger than the maximum theoretically supported physical memory.<br>**Note:** This register should not point to the LocalPlus Memory Space. This is not supported. |
| 2:27 | Reserved | These bits are reserved. |
| 28 | prefetchable access (pref) | Fixed to 1. This bit indicates that the memory space defined by BAR1 is prefetchable. Configuration software should write a 1 to this bit location. |
| 29:30 | range | Fixed to 00. This register indicates that base address 1 is 32 bits wide and can be mapped anywhere in 32-bit address space. Configuration software should write 00 to these bit locations. |
| 31 | IO or Memory Space (IO/M#) | Fixed to 0. This bit indicates that BAR1 is for memory space. Configuration software should write a 0 to this bit location.<br>0 = Memory<br>1 = I/O |

#### 10.3.1.7 CardBus CIS Pointer Register PCICCPR(RW)

MBAR + 0x0D28

This optional register contains the pointer to the Card Information Structure (CIS) for the CardBus card. All 32 bits of the register are programmable by the Slave bus. It can only be read from the PCI Bus. Its reset value is 0x00000000.

#### 10.3.1.8 Subsystem ID/ Subsystem Vendor ID Registers PCISID(R)—MBAR + 0x0D2C

The Subsystem Vendor ID register contains the 16-bit manufacturer identification number of the add-in board or subsystem that contains this PCI device. The Subsystem ID register contains the 16-bit subsystem identification number of the add-in board or subsystem that contains this PCI device. A value of zero in these registers indicates there isn't a Subsystem Vendor and Subsystem ID associated with the device. If used, software must write to these registers before any PCI bus master reads them.

All 32 bits of the register are programmable by the Slave bus. They can only be read from the PCI Bus. The reset value is 0x00000000.

#### 10.3.1.9 Expansion ROM Base Address PCIERBAR(R)

MBAR + 0x0D30

*Not implemented.* Fixed to 0x00000000.

#### 10.3.1.10 Capabilities Pointer (Cap_Ptr) PCICPR(R)

MBAR + 0x0D34

*Not implemented.* Fixed to 0x00000000.

### 10.3.1.11 Configuration 2 Register PCICR2 (R/RW)

MBAR + 0x0D3C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Maximum Latency | | | | | | | | Minimum Grant | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Interrupt Pin | | | | | | | | Interrupt Line | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-8. Configuration 2 Register PCICR2 (R/RW)**

**Table 10-10. Configuration 2 Register PCICR2 (R/RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | Maximum Latency (Max_Lat) | Specifies how often, in units of 1/4 microseconds, the PCI controller would like to have access to the PCI bus as master. A value of zero indicates the device has no stringent requirement in this area. The register is read/write to/from the Slave bus, but read only from the PCI bus.<br>**Note:** The MPC5200B does NOT support initiator latency time-outs, the internal PCI Arbiter does not support preemption of the internal masters XIPCI or SCPCI. The internal master is granted until the transaction has been completed. The Latency Timer (LT) cannot terminate any transfer. |
| 8:15 | Minimum Grant (Min_Gnt) | The value programmed to this register indicates how long the PCI controller as master would like to retain PCI bus ownership whenever it initiates a transaction. The register is programmable from the Slave bus, but read only from the PCI bus. |
| 16:23 | Interrupt Pin | Fixed to 0x00. Indicates that this device does **NOT** use an interrupt request pin. |
| 24:31 | Interrupt Line | Fixed to 0x00. The Interrupt Line register stores a value that identifies which input on a PCI interrupt controller the function's PCI interrupt request pin. Since no interrupt request pin is used, as specified in the Interrupt Pin register, this register has no function. |

## 10.3.2 General Control/Status Registers

The General Control/Status Registers primarily address the configurability of the XL bus Initiator and Target Interfaces, though some also address global options which affect the Multi-Channel DMA interface (BestComm). These registers are accessed primarily internally as offsets of MBAR, but can also be accessed by an external PCI master if PCI base and Target base address registers are configured to access the space. See Section 10.6.2, "Address Maps" on configuring address windows.

### 10.3.2.1 Global Status/Control Register PCIGSCR(RW)

MBAR + 0x0D60

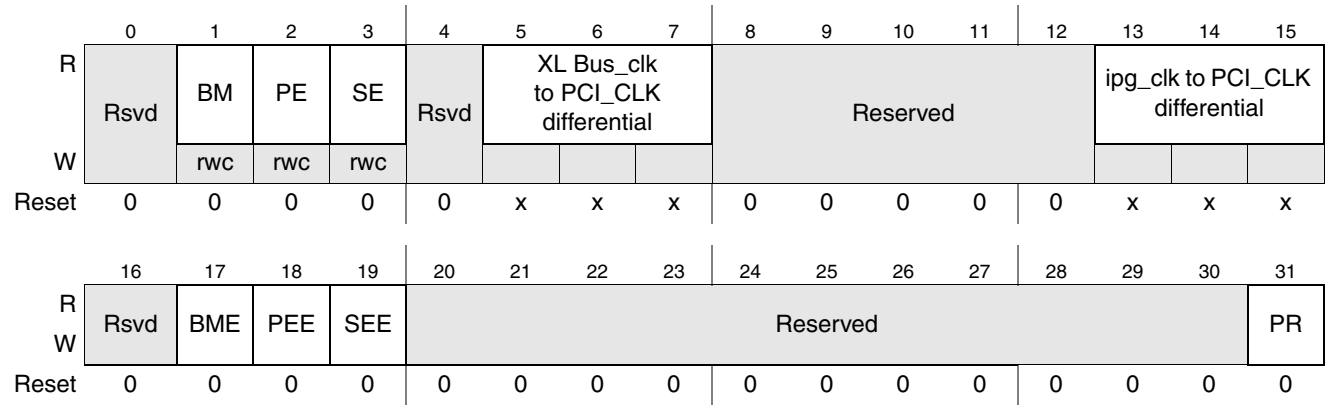



**Figure 10-9. Global Status/Control Register PCIGSCR(RW)**

**Table 10-11. Global Status/Control Register PCIGSCR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | Reserved | Unused bit. Software should write zero to this register. |
| 1 | Broken Master Detected (BM) | This bit is set when the PCI Arbiter detects a broken external PCI master.<br>**Note:** In case of broken master detection the external PCI request will be ignored until external deassertion of PCI request or until a software reset (PCI Arbiter Softreset) or by Hardreset is detected. After broken master detection (PCI bus idle for 16 clocks) the arbiter will ignore any FRAME# assertion.<br>A CPU interrupt will be generated if the PCIGSCR[BME] bit is set. This is a RWC (Read/WriteClear) bit: to clear it, software must write a ‘1’ at this position. |
| 2 | PERR Detected (PE) | This bit is set when the PCI Parity Error line, $\overline{\text{PERR}}$, asserts (any device). A CPU interrupt will be generated if the PCIGSCR[PEE] bit is set. This is a RWC (Read/WriteClear) bit: to clear it, software must write a ‘1’ at this position. |
| 3 | SERR Detected (SE) | This bit is set when a PCI System Error line, $\overline{\text{SERR}}$, asserts (any device). A CPU interrupt will be generated if the PCIGSCR[SEE] bit is set. This is a RWC (Read/WriteClear) bit: to clear it, software must write a ‘1’ at this position. |
| 4 | Reserved | Unused bit. Software should write zero to this register. |
| 5:7 | XL Bus_clk to PCI_CLK differential (read only) | This bit field stores the XL bus clock to the PCI clock divide ratio. This field is read-only and the reset value is determined by the PLL multiplier (either 1, 2, or 4). Software can read these bits to determine a valid ratio. If the register contains a differential value that does not reflect the PLL settings, the PCI controller could malfunction. |
| 8:12 | Reserved | Unused bits. Software should write zero to this register. |
| 13:15 | ipg_clk to PCI_CLK differential (read only) | This bit field stores the Slave bus clock to the PCI clock divide ratio. This field is read-only and the reset value is determined by the PLL multiplier (either 1, 2, or 4). Software can read these bits to determine a valid ratio. If the register contains a differential value that does not reflect the PLL settings, the PCI controller could malfunction. |
| 16 | Reserved | Unused bit. Software should write zero to this register. |
| 17 | Broken Master Interrupt Enable (BME) | This bit enables CPU Interrupt generation when a broken Master is detected. When enabled, software must clear the BM status bit to clear the interrupt condition. |

**Table 10-11. Global Status/Control Register PCIGSCR(RW) Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 18 | Parity Error Interrupt Enable (PEE) | This bit enables CPU Interrupt generation when the PCI Parity Error signal, $\overline{\text{PERR}}$, is sampled asserted. When enabled and $\overline{\text{PERR}}$ asserts, software must clear the PE status bit to clear the interrupt condition. |
| 19 | System Error Interrupt Enable (SEE) | This bit enables CPU Interrupt generation when a PCI System Error is detected on the $\overline{\text{SERR}}$ line. When enabled and $\overline{\text{SERR}}$ asserts, software must clear the SE status bit to clear the interrupt condition. |
| 20:30 | Reserved | Unused bits. Software should write zero to this register. |
| 31 | PCI Reset (PR) | This bit controls the external PCI $\overline{\text{RST}}$. When this bit is cleared, the external PCI $\overline{\text{RST}}$ deasserts. Setting this bit does not reset the internal PCI controller. The application software must not initiate PCI transactions while this bit is set. It is recommended that this bit be programmed last. The reset value of the bit is 1 (PCI $\overline{\text{RST}}$ asserted).<br>**Note:** A global PCI reset should be asserted just by the MPC5200B controller. Any external common reset controller signal will be ignored by the internal PCI controller. |

## 10.3.2.2 Target Base Address Translation Register 0 PCITBATR0(RW)

MBAR + 0x0D64

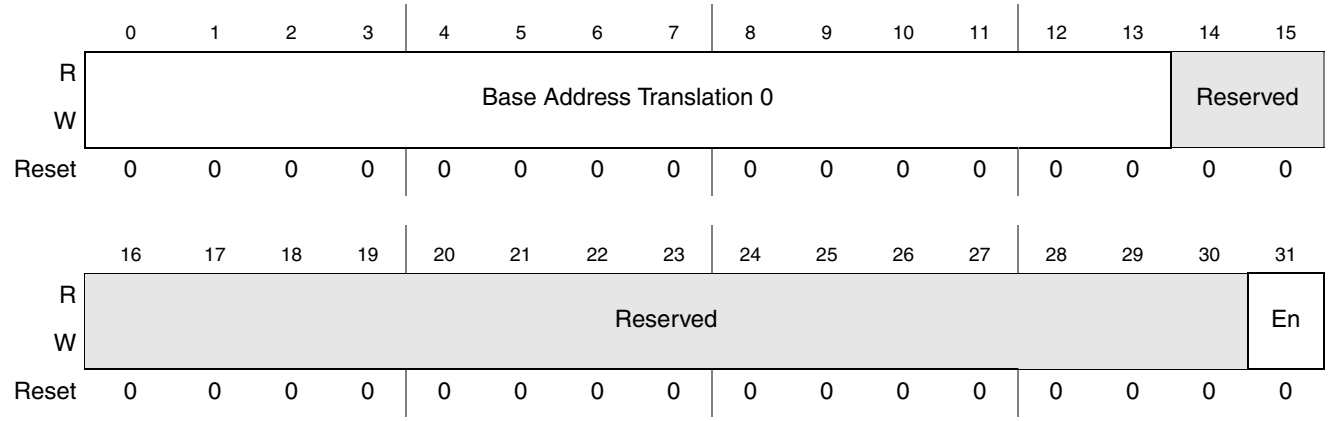



**Figure 10-10. Target Base Address Translation Register 0 PCITBATR0(RW)**

**Table 10-12. Target Base Address Translation Register 0 PCITBATR0(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:13 | Base Address Translation 0 | This base address register corresponds to a hit on the BAR0 in MPC5200B PCI Type 0 Configuration space register from PCI space. When there is a hit on MPC5200B PCI BAR0 (MPC5200B as Target), the upper 14 bits of the external PCI address (256Kbyte boundary) are written over by this register value to address some space in MPC5200B. In normal operation, this value should be written during the initialization sequence only to point to the internal Register space. |
| 14:30 | Reserved | Unused bits. Software should write zero to this register. |
| 31 | Enable 0 | This bit enables a transaction in BAR0 space. If this bit is zero and a hit on MPC5200B PCIBAR0 occurs, the target interface gasket will abort the PCI transaction. |

### 10.3.2.3 Target Base Address Translation Register 1 PCITBATR1(RW)

MBAR + 0x0D68

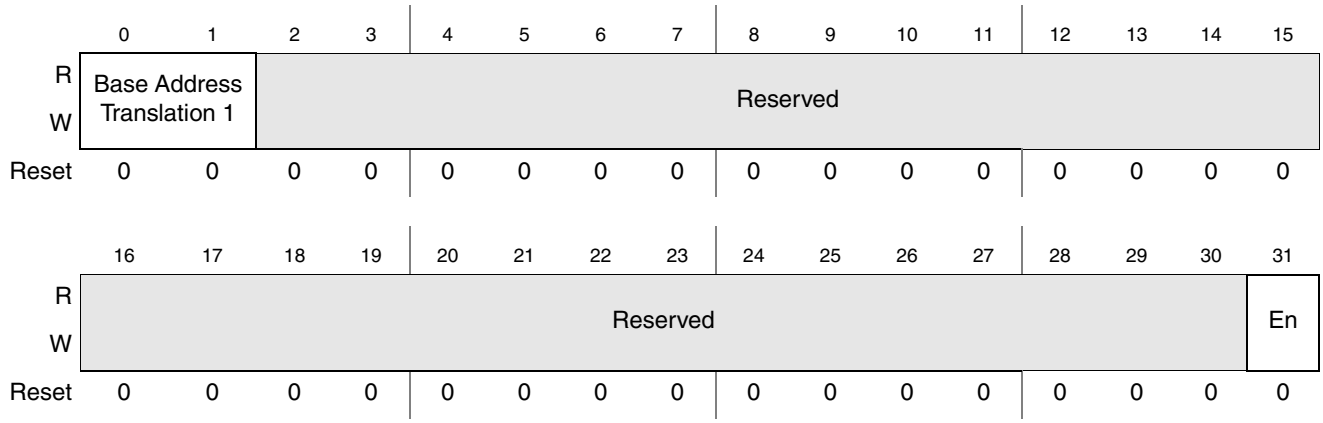



**Figure 10-11. Target Base Address Translation Register 1 PCITBATR1(RW)**

**Table 10-13. Target Base Address Translation Register 1 PCITBATR1(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:1 | Base Address Translation 1 | This base address register corresponds to a hit on the BAR1 in MPC5200B PCI Type 0 Configuration space register (PCI space). When there is a hit on MPC5200B PCI BAR1 (MPC5200B as Target), the upper 2 bits of the external PCI address (1Gbyte boundary) are written over by this register value to address some 1Gbyte space in MPC5200B. This register can be reprogrammed to move the window of MPC5200B address space accessed during a hit in PCIBAR1. It should be written by software during initialization to point to the internal SDR/DDR memory space.<br>**Note:** This register should not point to the LocalPlus Memory Space. This is not supported. |
| 2:30 | Reserved | Unused bits. Software should write zero to this register. |
| 31 | Enable 1 | This bit enables a transaction in BAR1 space. If this bit is zero and a hit on MPC5200B PCI BAR1 occurs, the target interface gasket will abort the PCI transaction. |

### 10.3.2.4 Target Control Register PCITCR(RW)

MBAR + 0x0D6C

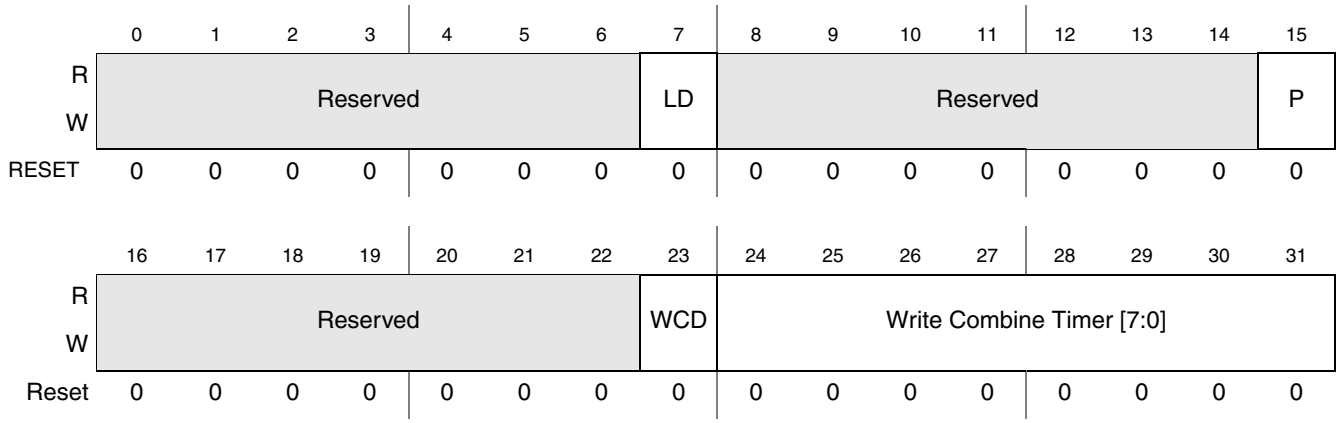



**Figure 10-12. Target Control Register PCITCR(RW)**

**Table 10-14. Target Control Register PCITCR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | Reserved | Unused bits. Software should write zero to this register. |
| 7 | Latrule Disable (LD) | This control bit applies only when MPC5200B is Target. When set, it prevents the PCI Controller from automatically issuing a retry disconnect due to the PCI 16/8 clock rule.<br>The bit must be set before the 15th PCI clock for the first transfer and before the 7th clock for other transfers. |
| 8:14 | Reserved | Unused bits. Software should write zero to this register. |
| 15 | Prefetch Reads (P) | This bit controls fetching a line from memory in anticipation of a request from the external master. The target interface will continue to prefetch lines from memory as long as PCI_FRAME is asserted and there is space to store the data in the target read buffer.<br>**Note:** This bit only applies to PCI reads in the address range for BAR 1 (prefetchable memory).<br>**Note:** Prefetching is performed in response to a PCI memory-read-multiple command even if this bit is cleared. |
| 16:22 | Reserved | Unused bits. Software should write zero to this register. |
| 23 | Write Combine Disable (WCD) | This control bit applies only when MPC5200 is Target. When set, it prevents the PCI Controller from automatically combining write data to be sent out on the XL bus as a burst, if possible. Instead, data is transferred as soon as possible on the XL bus as single-beat transactions.<br>Better target write performance is achieved when this bit cleared. |
| 24:31 | Write Combine Timer (WCT) | This register contains the timer value, in PCI clocks, used when a partial burst has been buffered in the target write data path and write data stops being transferred to local memory from the external PCI device. Every time a sequential beat of write data is stored in the buffer, the counter is reset with this value.<br>If partial burst data has been buffered, thereby activating the count-down counter, and this field is reprogrammed to a value less than the current counter value, the counter will jump down to the new write combine timer value. This way, software can force the write buffer to flush data to the XL bus more quickly than when the counter was initialized.<br>The reset value of the write combine timer is 0x08. All 8 bits are programmable. |

### 10.3.2.5 Initiator Window 0 Base/Translation Address Register PCIIW0BTAR(RW)

MBAR + 0x0D70

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Window 0 Base Address | | | | | | | | Window 0 Address Mask | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Window 0 Translation Address | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-13. Initiator Window 0 Base/Translation Address Register PCIIW0BTAR(RW)**

**Table 10-15. Initiator Window 0 Base/Translation Address Register PCIIW0BTAR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | Window 0 Base Address | One of three base address registers to determine an XL bus hit on PCI. At most, the upper byte of the address is decoded. The Window 0 Address Mask register determines what bits of this register to compare the XL bus address against to generate the hit.<br>**Note:** The smallest possible Window is a 16 MByte block. |
| 8:15 | Window 0 Address Mask | The Window 0 Address Mask Register masks the corresponding XL bus base address bit of the base address for Window 0 (Window 0 Base Address) to instruct the address decode logic to ignore or “don’t care” the bit. If the base address mask bit is set, the associated base address bit of Window 0 is ignored when generating the PCI hit. Bit 16 masks bit 24, bit 17 masks bit 25, and so on.<br>0 Corresponding address bit is used in address decode<br>1 Corresponding address bit is ignored in address decode<br>For XL Bus accesses to Window 0 address range, this byte also determines which upper 8 bits of the XL Bus address to pass on for presentation as a PCI address. Any address bit used to decode the XL Bus address, indicated by a “0”, will be translated. This provides a way to overlay a PCI page address onto the XL Bus address. A “1” in the Address Mask byte indicates that the XL Bus address bit will be passed to PCI unaltered. |
| 16:23 | Window 0 Translation Address | For any translated bit (described above), the corresponding value here will be driven onto the PCI address bus for the XL bus Window 0 address hit.<br>**Note:** The Window Translation operation can not be turned off. If a direct mapping from XL Bus to PCI space is desired, program the same value to both the Window Base Address Register and Window Translation Address Register. |
| 24:31 | Reserved | Unused bits. Software should write zero to this register. |

### 10.3.2.6 Initiator Window 1 Base/Translation Address Register PCIIW1BTAR(RW)

MBAR + 0x0D74

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Window 1 Base Address | | | | | | | | Window 1 Address Mask | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Window 1 Translation Address | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-14. Initiator Window 1 Base/Translation Address Register PCIIW1BTAR(RW)**

### 10.3.2.7 Initiator Window 2 Base/Translation Address Register PCIIW2BTAR (RW)

MBAR + 0x0D78

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Window 2 Base Address | | | | | | | | Window 2 Address Mask | | | | | | | |
| RESET | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Window 2 Translation Address | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-15. Initiator Window 2 Base/Translation Address Register PCIIW2BTAR(RW)**

### 10.3.2.8 Initiator Window Configuration Register PCIIWCR(RW)

MBAR + 0x0D80

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | Window 0 Control | | | | Reserved | | | | Window 1 Control | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | Window 2 Control | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-16. Initiator Window Configuration Register PCIIWCR(RW)**

**Table 10-16. Initiator Window Configuration Register PCIIWCR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | Reserved | Reserved register. Write a zero to this register. |
| 4:7 | Window 0 Control [3:0] | Bit[3] - IO/M#.<br>0 = Window is mapped to PCI memory<br>1 = Window is mapped to PCI I/O<br>Bit[2:1] - PCI Read Command (PRC).<br>If bit[3] is programmed memory, “0”, then these bits are used to determine the type of PCI memory command to issue. See <Cross Refs Helv 9>Table 10-63. If bit[3] is set to “1”, the value of these bits are meaningless.<br>00 = PCI Memory Read<br>01 = PCI Memory Read Line<br>10 = PCI Memory Read Multiple<br>11 = Reserved<br>**Note:** A PCI write command is automatically detected and needs not to be explicitly configured. No PCI Write and Invalidate command is allowed in any case with this interface.<br>Bit[0] - Enable.<br>This bit is set to indicate the address registers that control the XL Bus initiator interface access to PCI initialized and will be used. The PCI Controller can begin to decode XL Bus PCI accesses.<br>0 = Do not decode XL Bus PCI accesses to Window<br>1 = Registers initialized - decode accesses to Window |
| 8:11 | Reserved | Reserved register. Write a zero to this register. |
| 12:15 | Window 1Control [3:0] | Bit[3] - IO/M#.<br>Bit[2:1] - PRC.<br>Bit[0] - Enable. |
| 16:19 | Reserved | Reserved register. Write a zero to this register. |
| 20:23 | Window 0 Control [3:0] | Bit[3] - IO/M#.<br>Bit[2:1] - PRC.<br>Bit[0] - Enable. |
| 24:31 | Reserved | Reserved register. Write a zero to this register. |

### 10.3.2.9 Initiator Control Register PCIICR(RW)

MBAR + 0x0D84

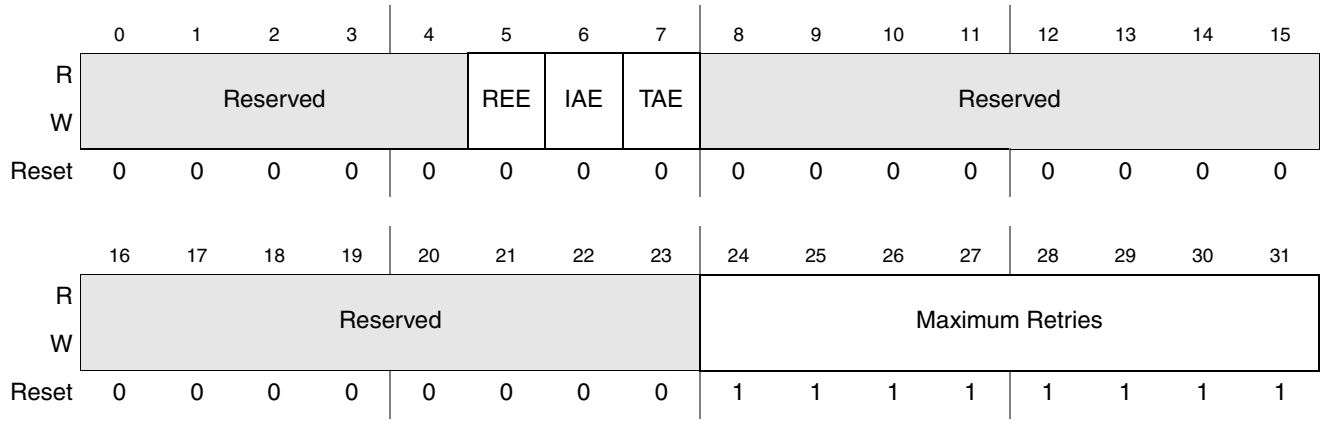



**Figure 10-17. Initiator Control Register PCIICR(RW)**

**Table 10-17. Initiator Control Register PCIICR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:4 | Reserved | Unused bits. Software should write zero to this register. |
| 5 | Retry Error Enable (RE) | This bit enables CPU Interrupt generation in the case of Retry Error termination of a packet transmission. It may be desirable to mask CPU interrupts, but in such a case, software should poll the status bits to prevent a possible lock-up condition. |
| 6 | Initiator Abort Enable (IAE) | This bit enables CPU Interrupt generation in the case of Initiator Abort termination of a packet transmission. It may be desirable to mask CPU interrupts, but in such a case, software should poll the status bits to prevent a possible lock-up condition. |
| 7 | Target Abort Enable (TAE) | This bit enables CPU Interrupt generation in the case of Target Abort termination of a packet transmission. It may be desirable to mask CPU interrupts, but in such a case, software should poll the status bits to prevent a possible lock-up condition. |
| 8:23 | Reserved | Unused bits. Software should write zero to this register. |
| 24:31 | Maximum Retries | This bit field controls the maximum number of automatic PCI retries to permit per transaction. The retry counter is reset at the beginning of each transaction (i.e. it is not cumulative). Setting the Maximum Retries to 0x00 allows infinite automatic retry cycles.<br>A finite (0x01 to 0xff) Maximum Retries value will detect the maximum PCI retries and the next retry will abort the transaction. For a Write transaction an interrupt will be generated, for a Read transaction an interrupt and a TEA on the XL Bus will be generated. |

### 10.3.2.10 Initiator Status Register PCIISR(RWC)

MBAR + 0x0D88

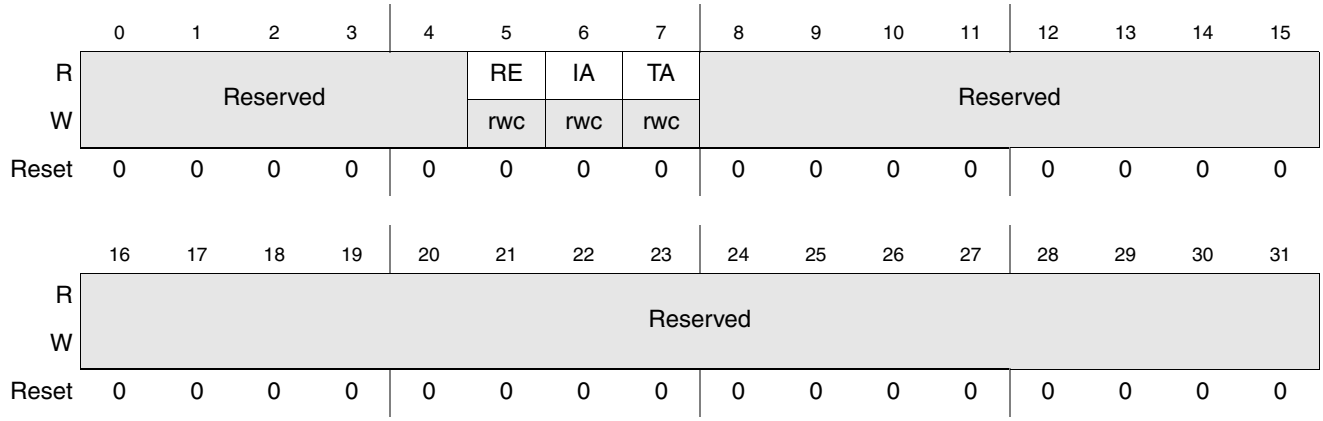



**Figure 10-18. Initiator Status Register PCIISR(RWC)**

**Table 10-18. Initiator Status Register PCIISR(RWC) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:4 | Reserved | Unused bits. Software should write zero to this register. |
| 5 | Retry Error (RE) | This flag is set if Max_Retries is set to a finite value (0x01 through 0xff) and the Target has performed Max_Retries number of retry disconnects for a single transaction. A retry error would generally indicate a broken or improperly accessed Target. A CPU interrupt will be generated if PCIICR[RE] bit is set. This is a RWC (Read/WriteClear) bit: to clear it, software must write a ‘1’ at this position. |
| 6 | Initiator Abort (IA) | This flag bit is set if the PCI controller issues an Initiator Abort flag. This indicates that no Target responded by asserting $\overline{\text{DEVSEL}}$ within the time allowed for subtractive decoding. A CPU interrupt will be generated if the PCIICR[IAE] bit is set. This is a RWC (Read/WriteClear) bit: to clear it, software must write a ‘1’ at this position. |
| 7 | Target Abort (TA) | This flag bit is set if the addressed PCI Target has signalled an Abort. A CPU interrupt will be generated if the PCIICR[TAE] bit is set. It is up to application software to query the Target’s status register and determine the source of the error. This is a RWC (Read/WriteClear) bit: to clear it, software must write a ‘1’ at this position. |
| 8:31 | Reserved | Unused bits. Software should write zero to this register. |

### 10.3.2.11 PCI Arbiter Register PCIARB(RW)

MBAR + 0x0D8C

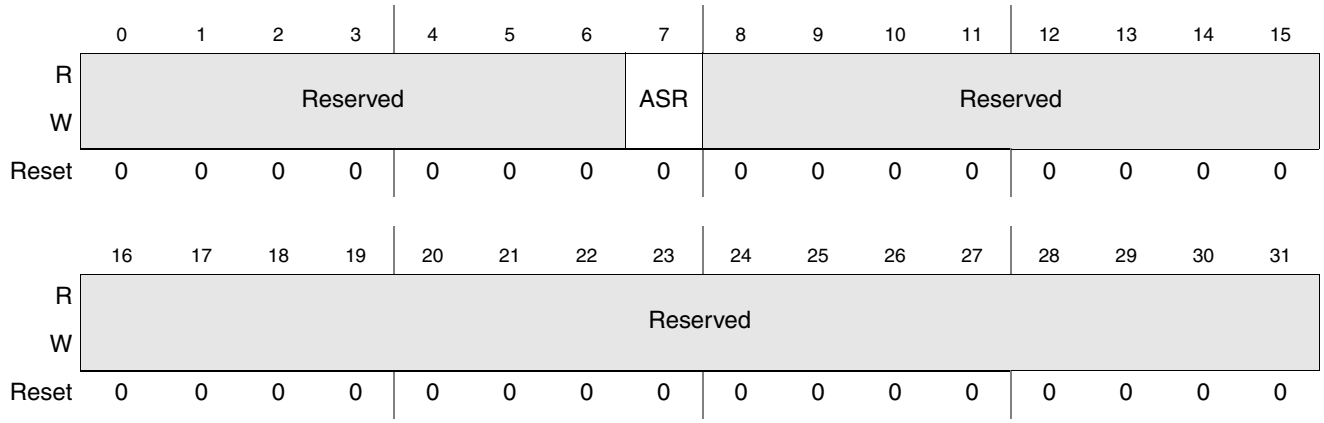



**Figure 10-19. PCI Arbiter Register PCIARB(RW)**

**Table 10-19. PCI Arbiter Register PCIARB(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | Reserved | Unused bits. Software should write zero to this register. |
| 7 | PCI Arbiter Soft Reset (ASR) | This bit puts the PCI Arbiter in a reset condition.<br>1 = reset the PCI Arbiter<br>0 = release the PCI Arbiter<br>**Note:** Resetting the PCI arbiter will disrupt any related transaction in progress and should be reserved only for error conditions, or when it is known that no PCI or AD bus transactions are in progress. |
| 8:31 | Reserved | Unused bits. Software should write zero to this register. |

### 10.3.2.12 Configuration Address Register PCICAR(RW)

MBAR + 0x0DF8

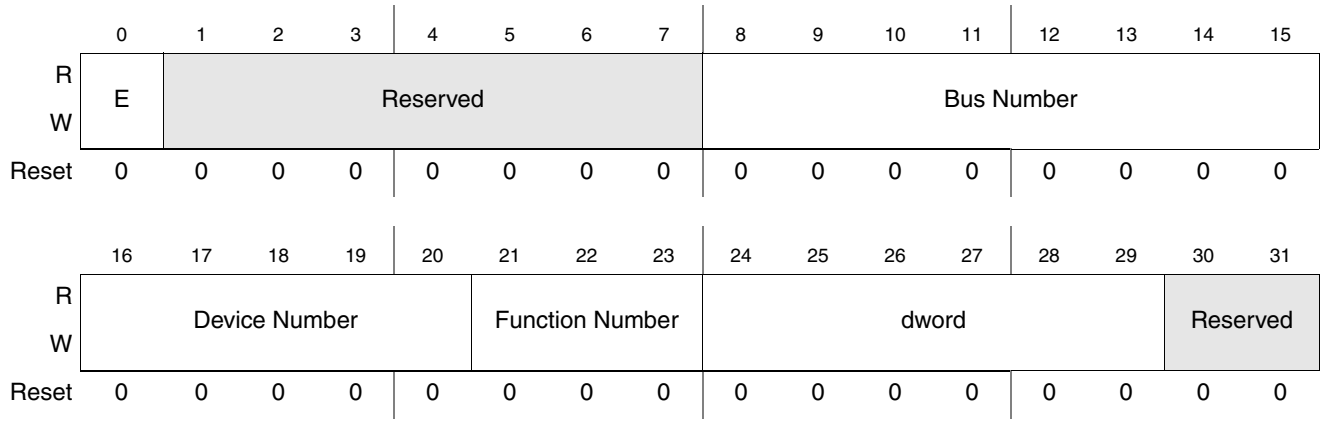



**Figure 10-20. Configuration Address Register PCICAR (RW)**

**Table 10-20. Configuration Address Register PCICAR (RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | Enable (E) | The enable flag that controls configuration space mapping. When enabled, subsequent access to initiator window space defined as I/O in the PCIIWCR is translated into a PCI configuration access using the Configuration Address Register information (<Cross Refs Helv 9>Section 10.6, <Cross Refs Helv Italic 9>Application Information). When disabled, a read or write to the window is passed through to the PCI bus as an I/O transaction using the.<br>1 = Enabled<br>0 = Disabled |
| 1:7 | Reserved | Unused bits. Software should write zero to this register. |
| 8:15 | Bus Number | This register field is an encoded value used to select the target bus of the configuration access. For target devices on the PCI bus connected to MPC5200B, this field should be set to 0x00. |
| 16:20 | Device Number | This field is used to select a specific device on the target bus. |
| 21:23 | Function Number | This field is used to select a specific function in the requested device. Single-function devices should respond to function number 0b000. |
| 24:29 | dword | This field is used to select the dword address offset in the configuration space of the target device. |
| 30:31 | Reserved | Unused bits. Software should write zero to this register. |

## 10.3.3 Communication Sub-System Interface Registers

The Communication Sub-System/Multi-Channel DMA interface (also shortly referred to as SCPCI) has separate control registers for transmit and receive operations.

### 10.3.3.1 Multi-Channel DMA Transmit Interface

PCI Tx is controlled by 14 ‘32-bit’ registers. These registers are located at an offset 0x3800 from MBAR. Register addresses are relative to this offset.

#### 10.3.3.1.1 Tx Packet Size PCITPSR(RW)

MBAR + 0x3800

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Packet_Size[31:16] | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Packet_Size[15:2] | | | | | | | | | | | | | | PacketSize[1:0] | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 10-21. Tx Packet Size PCITPSR(RW)**

**Table 10-22. Tx Packet Size PCITPSR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Packet_Size | User writes the number of bytes for transmit controller to send over PCI.The two low bits are hardwired low; only 32-bit data transfers to the FIFO are allowed. Writing to this register also completes a Restart Sequence as long as the Master Enable bit, PCITER[ME], is high and Reset Controller bit, PCITER[RC], is low. |

### 10.3.3.1.2 Tx Start Address PCITSAR(RW)

MBAR + 0x3804

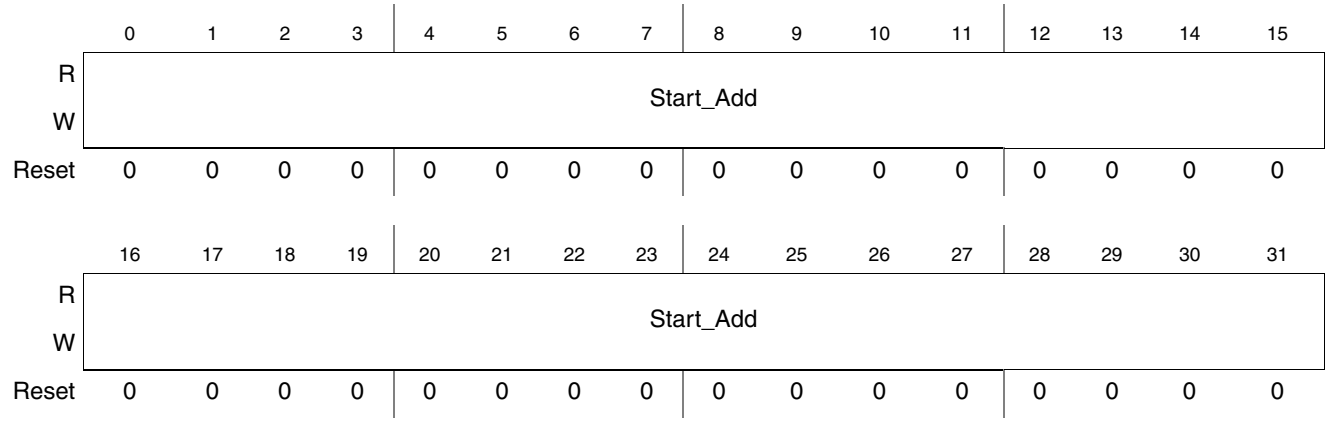



**Figure 10-21. Tx Start Address PCITSAR(RW)**

**Table 10-23. Tx Start Address PCITSAR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Start_Add | User writes the PCI address to be presented for the first DWORD (32 bit) of a PCI packet. The PCI Tx controller will track and calculate the necessary address for subsequent transactions (addressing is assumed to be sequential from the start address). |

### 10.3.3.1.3 Tx Transaction Control Register PCITTCR(RW)

MBAR + 0x3808

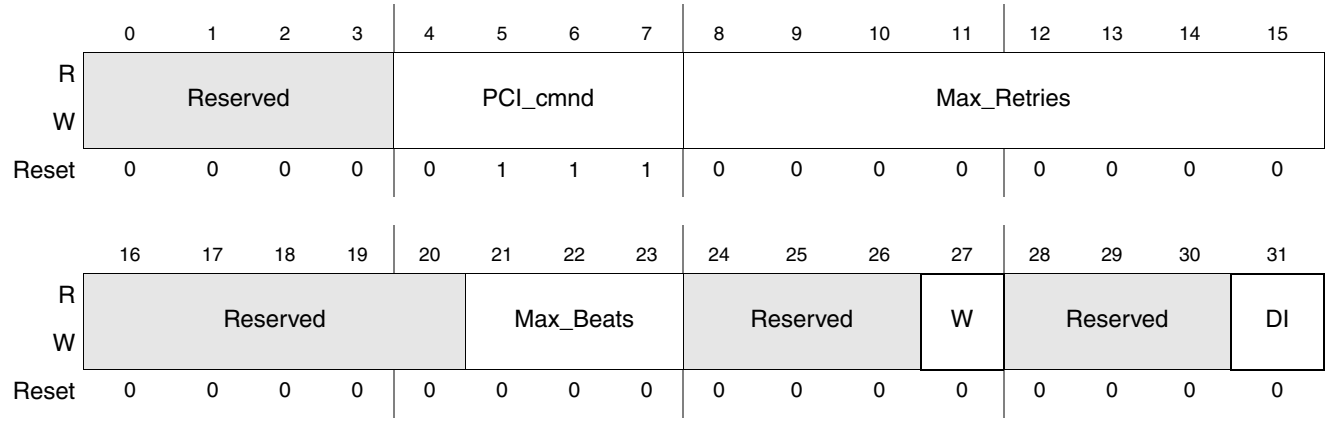



**Figure 10-22. Tx Transaction Control Register PCITTCR(RW)**

**Table 10-24. Tx Transaction Control Register PCITTCR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | Reserved | Unused. Software should write zero to these bits. |
| 4:7 | PCI_cmd | The user writes this field with the desired PCI command to present during the address phase of each PCI transaction. The default is Memory Write. This field is not checked for consistency and if written to an illegal value, unpredictable results will occur. If not using the default value, the user should write this register only once prior to any packet Restart. |
| 8:15 | Max_Retries | The user writes this field with the maximum number of retries to permit per packet. The retry counter is reset when the packet completes normally or is terminated by a master abort, target abort, or an abort due to exceeding the retry limit. A slow or malfunctioning Target might issue infinite disconnects and therefore permanently tie up the PCI bus.<br>A finite (0x01 to 0xff) Max_Retries value will detect this condition and generate an interrupt. Setting Max_Retries to 0x00 will not generate any interrupt. |
| 16:20 | Reserved | Unused bits. Software should write zero to these bits. |
| 21:23 | Max_Beats | The user writes this register with the desired number of PCI data beats to attempt on each PCI transaction. The default setting of 0 represents the maximum of eight beats per transaction. The transmit controller will wait until sufficient bytes are in the Transmit FIFO to support the indicated number of beats (NOTE: Each beat is four bytes). In the case that a packet is nearly complete and less than the Max_Beats number of bytes remain to complete the packet, the Transmit Controller will issue single-beat transactions automatically until the packet is finished. |
| 24:26 | Reserved | Unused. Software should write zero to these bits. |
| 27 | Word Transfer (W) | The user writes this register to disable the two high byte enables of the PCI bus during SCPCI initiated write transactions. The default setting is 0, enable all 4 byte enables. |
| 28:30 | Reserved | Unused. Software should write zero to these bits. |
| 31 | Disable address Incrementing (DI) | The user writes this register to disable PCI address incrementing between transactions. The default setting is 0, incrementing the address by 4 (4 byte data bus).<br>**Note:** This feature is recommended when an external FIFO (with a fixed address) must be written. |

### 10.3.3.1.4 Tx Enables PCITER(RW)

MBAR + 0x380C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | RC | RF | Rsvd | CM | BE | Reserved | | ME | Reserved | | FEE | SE | RE | TAE | IAE | NE |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-23. Tx Enables PCITER(RW)**

**Table 10-25. Tx Enables PCITER(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | Reset Controller (RC) | User writes this bit high to put Transmit Controller in a reset state. Other register bits are not affected. This Reset is intended for recovery from an error condition or to reload the Start Address when Continuous mode is selected. This Reset bit does not prohibit register access but it must be negated in order to initiate a Restart sequence (i.e. writing the Packet_Size register). If it is used to reload a Start Address then the Start_Add register must be written prior to asserting this Reset bit.<br>Setting the Reset Controller bits in either PCITER or PCIRER can cause the PCI interface and the PCI bus to hang if these bits are set while the PCI interface is currently executing a PCI transaction. To terminate PCI data transfers across the PCI communication sub-system Tx and/or Rx interface(s) safely, follow steps 1 through 5 in order.<br>1. Kill the DMA task associated with the appropriate channel (PCI Tx or PCI Rx) to stop the internal transfer of data to or from the PCI FIFOs<br>2. Reprogram the Max_Beats field of the appropriate PCI interface register, PCITTCR or PCIRTCR, to 1<br>3. Wait for the FIFO to fill (Rx) or empty (Tx) by polling the FIFO status registers.<br>4. Assert Reset Controller bit for the appropriate interface.<br>5. Assert Reset FIFO bit for the appropriate interface. |
| 1 | Reset FIFO (RF) | The FIFO will be reset and flushed of any existing data when set high. The Reset Controller bit and the Reset FIFO bit operate independently but clearly both must be low for normal operation. |
| 2 | Reserved | Unused bit. Software should write a zero to this bit. |
| 3 | Continuous mode (CM) | User writes this bit high to activate Continuous mode. In Continuous mode the Start_Add value is ignored at each packet restart and the PCI address is auto-incremented from one packet to the next. Also, the Packets_Done status byte will become active, indicating how many packets have been transmitted since the last Reset Controller condition. If the Continuous bit is low, software is responsible for updating the Start_Add value at each packet Restart. |
| 4 | Bus error Enable (BE) | User writes this bit high to enable Bus Error indications. <Cross Refs Helv 9>Section 10.3.3.1.9, <Cross Refs Helv Italic 9>Tx Status PCITSR(RWC) for Bus Error descriptions. Normally this bit will be low (negated) since illegal Slave bus accesses are not destructive to register contents (although it may indicate broken software). This bit does not affect interrupt generation. |
| 5:6 | Reserved | Unused. Software should write zero to these bits. |

**Table 10-25. Tx Enables PCITER(RW) Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 7 | Master Enable (ME) | This is the Transmit Controller master enable signal. User must write it high to enable operation. It can be toggled low to permit out-of-order register updates prior to generating a Restart sequence (in which case transmission will begin when Master Enable is written back high), but it should not be used as such in Continuous mode because it has the side effect of resetting the Packets_Done status counter. |
| 8:9 | Reserved | Unused. Software should write zero to these bits. |
| 10 | FIFO Error Enable (FEE) | User writes this bit high to enable CPU Interrupt generation in the case of FIFO error termination of a packet transmission. It may be desirable to mask CPU interrupts in the case that Multi-Channel DMA is controlling operation, but in such a case software should poll the status bits to prevent a possible lock-up condition. |
| 11 | System error Enable (SE) | User writes this bit high to enable CPU Interrupt generation in the case of system error termination of a packet transmission. It may be desirable to mask CPU interrupts in the case that Multi-Channel DMA is controlling operation, but in such a case someone should be polling the status bits to prevent a possible lock-up condition. |
| 12 | Retry abort Enable (RE) | User writes this bit high to enable CPU Interrupt generation in the case of retry abort termination of a packet transmission. It may be desirable to mask CPU interrupts in the case that Multi-Channel DMA is controlling operation, but in such a case software should poll the status bits to prevent a possible lock-up condition. |
| 13 | Target Abort Enable (TAE) | User writes this bit high to enable CPU Interrupt generation in the case of target abort termination of a packet transmission. It may be desirable to mask CPU interrupts in the case that Multi-Channel DMA is controlling operation, but in such a case software should poll the status bits to prevent a possible lock-up condition. |
| 14 | Initiator Abort Enable (IAE) | User writes this bit high to enable CPU Interrupt generation in the case of initiator abort termination of a packet transmission. It may be desirable to mask CPU interrupts in the case that Multi-Channel DMA is controlling operation, but in such a case software should poll the status bits to prevent a possible lock-up condition. |
| 15 | Normal termination Enable (NE) | User writes this bit high to enable CPU Interrupt generation at the conclusion of a normally terminated packet transmission. This may or may not be desirable depending on the nature of program control by Multi-Channel DMA or the processor core. |
| 16:31 | Reserved | Unused. Software should write zero to these bits. |

### 10.3.3.1.5 Tx Next Address PCITNAR(R)

MBAR + 0x3810

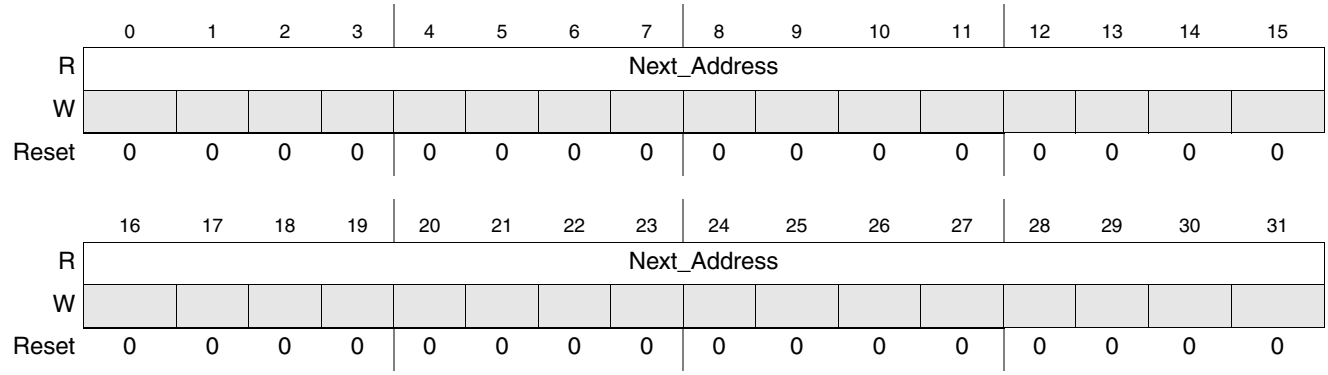



**Figure 10-24. Tx Next Address PCITNAR(R)**

**Table 10-26. Tx Next Address PCITNAR(R) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Next_Address | This status register contains the next (unwritten) PCI address and is updated at the successful completion of each PCI data beat. It represents a byte address and is updated with the user-written Start_Add value whenever the Start_Add is reloaded. It is intended to be accurate even in the case of abnormal terminations on the PCI bus. |

### 10.3.3.1.6 Tx Last Word PCITLWR(R)

MBAR + 0x3814

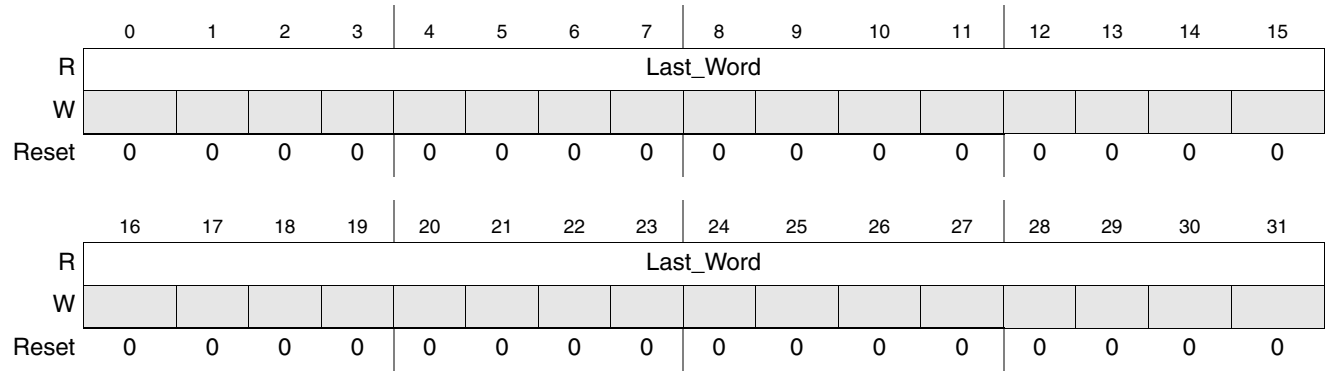



**Figure 10-25. Tx Last Word PCITLWR(R)**

**Table 10-27. Tx Last Word PCITLWR(R) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Last_Word | This status register indicates the last 32-bit data fetched from the FIFO and is designed for the case in which an abnormal PCI termination has corrupted the integrity of the FIFO data (for that word). |

### 10.3.3.1.7 Tx Bytes Done Counts PCITDCR(R)

MBAR + 0x3818

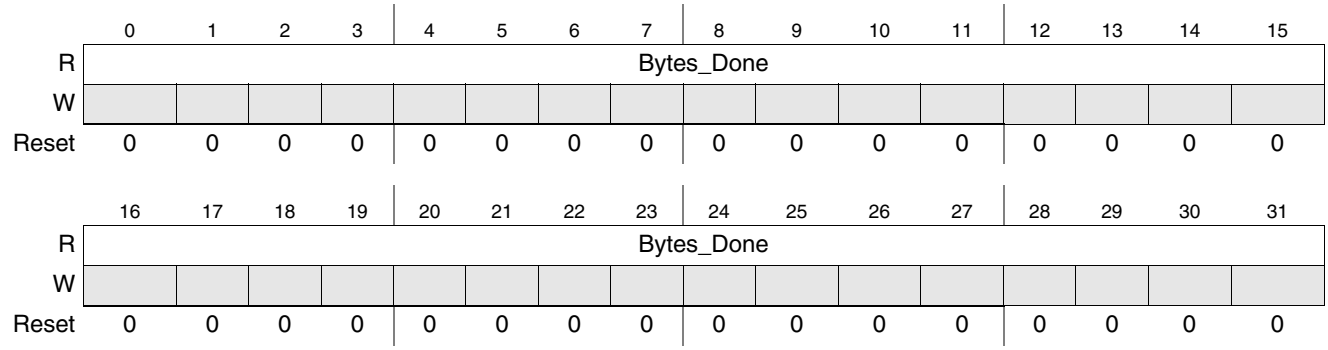



**Figure 10-26. Tx Bytes Done Counts PCITDCR(R)**

**Table 10-28. Tx Bytes Done Counts PCITDCR(R) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Bytes_Done | This status register indicates the number of bytes transmitted since the start of a packet. It is updated at the end of each successful PCI data beat. For normally terminated packets the Bytes_Done value and the Packet_Size values will be equal. If Continuous Mode is active the Bytes_Done value will read zero at the end of a successful packet and the Packets_Done field will be incremented. |

### 10.3.3.1.8 Tx Packets Done Counts PCITPDCR(R)

MBAR + 0x3820

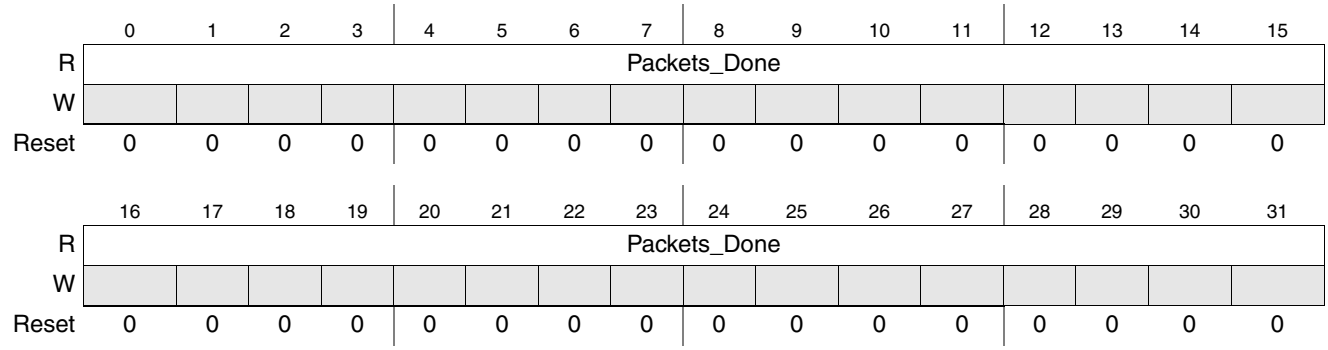



**Figure 10-27. Tx Packets Done Counts PCITPDCR(R)**

**Table 10-29. Tx Packets Done Counts PCITPDCR(R) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Packets_Done | This status register indicates the number of packets transmitted and is active only if continuous mode is in effect. The counter is reset if the following occurs:<br>• Reset Controller bit, PCITER[RC], is asserted (normal way to restart continuous mode)<br>• Master Enable bit, PCITER[ME], becomes negated<br>Master enable can reset Packets_Done status without disturbing continuous mode addressing. At any point in time, the total number of Bytes transmitted can be calculated as:<br>(Packets_Done x Packet_Size) + Bytes_Done<br>assuming Packet_Size is the same for all restart sequences |

### 10.3.3.1.9 Tx Status PCITSR(RWC)

MBAR + 0x381C

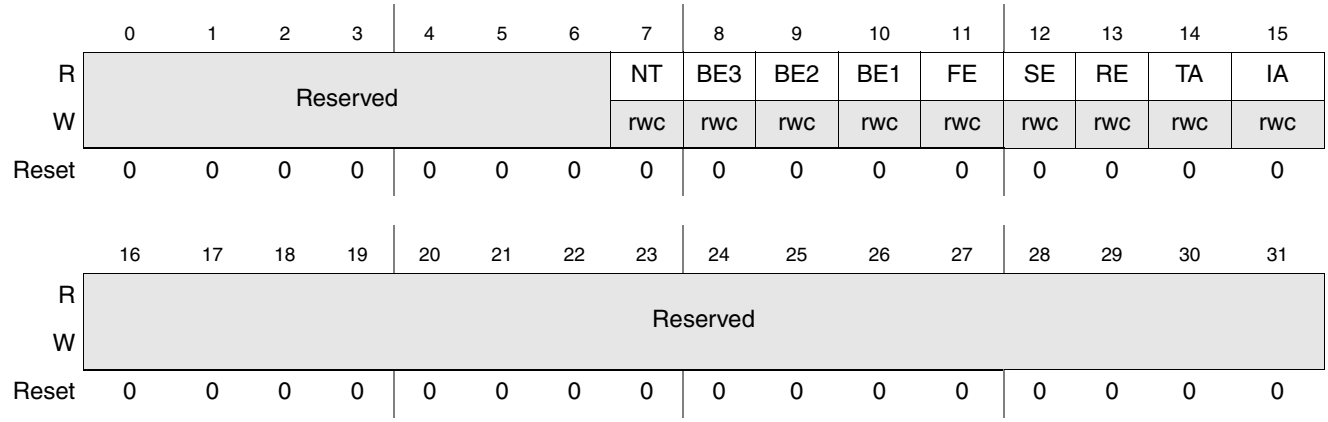



**Figure 10-28. Tx Status PCITSR(RWC)**

**Table 10-30. Tx Status PCITSR(RWC) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | Reserved | Unused. Software should write zero to these bits. |
| 7 | Normal Termination (NT) | This flag is set when any packet terminates normally. It is NOT set for abnormally terminated packets.<br>**Note:** Flag does not **require** clearing, but does not clear until 1 is written, in which case 0 is read back (i.e., negated). The following flag bits operate similarly. |
| 8 | Bus Error type 3 (BE3) | This flag is set whenever a Slave bus transaction attempts to write to a Read-Only register. This flag bit is set regardless of the Bus error Enable bit (BE). If software is polling this Byte and wishes to disregard this error it must mask this bit out.<br>No register bit corruption occurs for this (or any other) bus error case. |
| 9 | Bus Error type 2 (BE2) | This flag is set whenever a Slave bus transaction attempts to write to a Reserved register (an entire 32-bit register, not just a Reserved bit or byte). This flag bit is set regardless of the Bus error Enable bit (BE). If software is polling this Byte and wishes to disregard this error it must mask this bit out. |
| 10 | Bus Error type 1 (BE1) | This flag is set whenever a Slave bus transaction attempts to read a Reserved register (an entire 32-bit register, not just a Reserved bit or byte). This flag bit is set regardless of the Bus error Enable bit (BE). If software is polling this Byte and wishes to disregard this error it must mask this bit out. |
| 11 | FIFO Error (FE) | This flag is set whenever the Transmit FIFO asserts its FIFO Error output. A CPU interrupt will be generated if the FIFO Error Enable (FEE) bit is set. The source of the error must be determined by reading the FIFO Error status register. Also, the error condition must be cleared at the FIFO prior to clearing this Sticky bit or this flag will continue to assert. |
| 12 | System Error (SE) | This flag is set in response to the Transmit Controller entering an illegal state. A CPU interrupt will be generated if the System error Enable (SE) bit is set. In normal operation this should never occur. The only recovery is to assert the Reset Controller bit, PCITER[RC], and clear this flag. |
| 13 | Retry Error (RE) | This flag is set if Max_Retries is set to a finite value (0x01 to 0xff) and the PCI transaction has performed retries in excess of the setting. A CPU interrupt will be generated if the Retry error Enable (RE) bit is set. The retry counter is reset at the beginning of each transaction (i.e. it is not cumulative throughout a packet) and would generally indicate a broken or improperly accessed Target. |

**Table 10-30. Tx Status PCITSR(RWC) Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 14 | Target Abort (TA) | This flag bit is set if the PCI controller has issued a Target Abort (which means the addressed PCI Target has signalled an Abort). A CPU interrupt will be generated if the Target Abort Enable (TAE) bit is set. It is up to application software to query the Target's status register and determine the source of the error. The coherency of the Transmit FIFO data and the Transmit Controller's status registers (Next_Address, Bytes_Done, etc.) should remain valid. |
| 15 | Initiator Abort (IA) | This flag bit is set if the PCI controller issues an Initiator Abort flag. This indicates that no Target responded but further status information can be read from the PCI Configuration interface. A CPU interrupt will be generated if the Initiator Abort error Enable (IAE) bit is set. The coherency of the Transmit FIFO data and the Transmit Controller's status registers (Next_Address, Bytes_Done, etc.) should remain valid. |
| 16:31 | Reserved | Unused. Software should write zero to these bits. |

## 10.3.3.1.10 Tx FIFO Data Register PCITFDR(RW)

MBAR + 0x3840

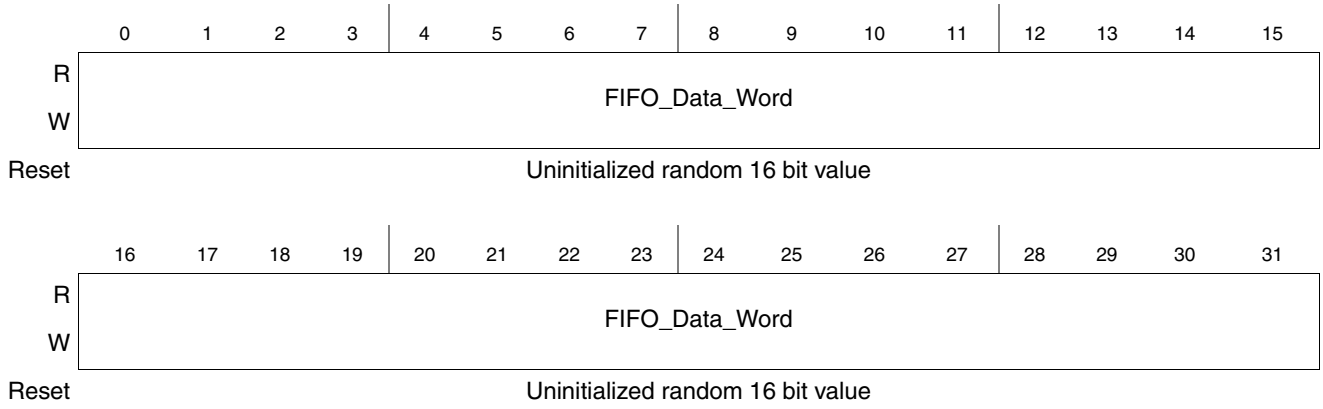

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
R
W
FIFO_Data_Word
Reset
Uninitialized random 16 bit value
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
R
W
FIFO_Data_Word
Reset
Uninitialized random 16 bit value

**Figure 10-29. Tx FIFO Data Register PCITFDR(RW)**

**Table 10-31. Tx FIFO Data Register PCITFDR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | FIFO_Data_Word | This is the data port to the FIFO. Reading from this location will "pop" data from the FIFO, writing data will "push" data into the FIFO. During normal operation the Multi-Channel DMA controller will be pushing data here. The PCI controller will pop data for transmission from a dedicated peripheral port, so the user program should not be reading here. At reset any uninitialized random 32 bit value is read at this address. A FIFO reset must be always performed before first accessing the FIFO.<br>**Note:** Only full 32-bit accesses are allowed. If all Byte enables are not asserted when accessing this location, FIFO data will be corrupted. |

### 10.3.3.1.11 Tx FIFO Status Register PCITFSR(R/RWC)

MBAR + 0x3844

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | RXW | UF | OF | FR | Full | Alarm | Empty |
| W | | | | | | | | | | rwc | rwc | rwc | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-30. Tx FIFO Status Register PCITFSR(R/RWC)**

**Table 10-32. Tx FIFO Status Register PCITFSR(R/RWC) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:8 | Reserved | Unused. Software should write zero to these bits. |
| 9 | Receive Wait Condition (RXW) | This flag bit indicates that the ipf_rcv bus is incurring wait states because there is not enough room in the FIFO to accept the data without causing overflow. This bit will cause the error outputs (fifoError, ipf_rcv_error, ipf_xmit_error) to assert unless the RXW_MASK bit in the FIFO Control register is set. Resetting the FIFO will clear this condition and the flag bit is cleared by writing a one to its bit position. |
| 10 | UnderFlow (UF) | This flag bit indicates that the read pointer has surpassed the write pointer. In other words the FIFO has been read beyond Empty. Resetting the FIFO will clear this condition and the flag bit is cleared by writing a one to its bit position. |
| 11 | OverFlow (OF) | This flag bit indicates that the write pointer has surpassed the read pointer. In other words the FIFO has been written beyond Full. Resetting the FIFO will clear this condition and the flag bit is cleared by writing a one to its bit position. |
| 12 | Frame Ready (FR) | The FIFO has a complete Frame of data ready for transmission. This module does not provide support for Data Framing applications, so this bit should be ignored. |
| 13 | Full | The FIFO is Full. This is not a sticky bit or error condition. The Full indication tracks with the state of the FIFO. |
| 14 | Alarm | When the FIFO pointer is at or below the Alarm “watermark”, as written by the user according to the Alarm and Control registers settings, this bit is set, automatically signalling to the DMA engine the need to re-fill the FIFO. By writing a ‘1’ to this bit software can enforce a re-evaluation of the ‘alarm’ condition. |
| 15 | Empty | The FIFO is empty. This is not a sticky bit or error condition. |
| 16:31 | Reserved | Unused. Software should write zero to these bits. |

### 10.3.3.1.12 Tx FIFO Control Register PCITFCR(RW)

MBAR + 0x3848

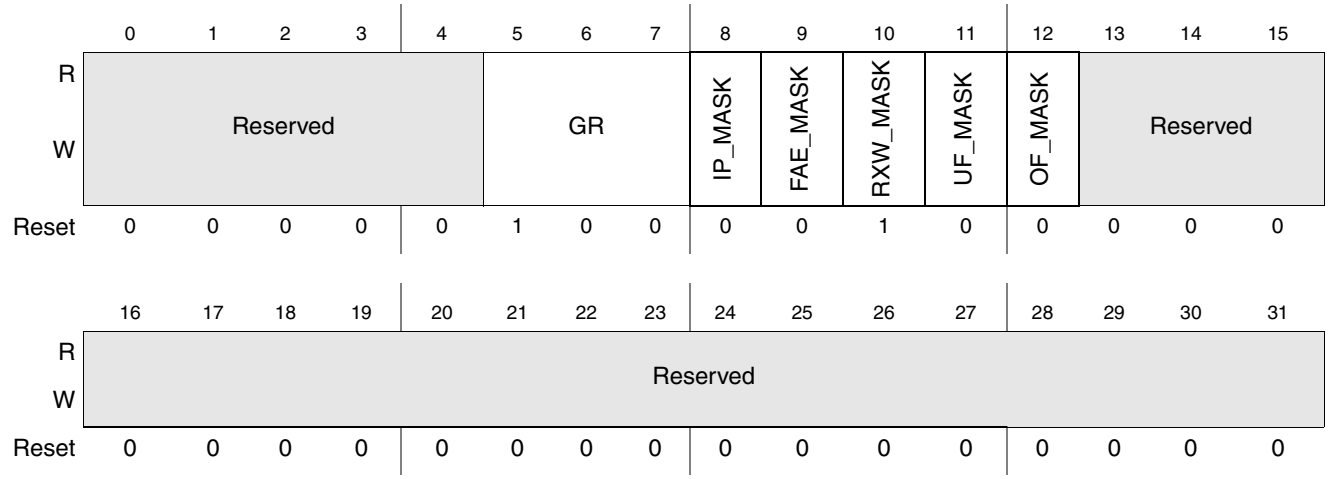



**Figure 10-31. Tx FIFO Control Register PCITFCR(RW)**

**Table 10-33. Tx FIFO Control Register PCITFCR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:4 | Reserved | Unused. Software shall write zero to these bits. (R/W) |
| 5:7 | Granularity (GR) | Granularity bits control high “watermark” point at which FIFO negates Alarm condition (i.e., request for data). It represents the number of free Bytes, which is given by the granularity value multiplied by 4.<br>**Note:** A granularity setting of zero should be avoided because it means the Alarm bit (and the Requestor signal) will not negate until the FIFO is completely full. The Multi-Channel DMA module may perform up to 2 additional data writes after the negation of a Requestor due to its internal pipelining<br>**Note:** This field must be set to a value of 4 or higher. When the FIFO granularity is 0 - 3, read data can be corrupted with no error indication when the PCI controller simultaneously writes to the same location that the BestComm is reading from. The workaround is to use a FIFO granularity of 4 or greater. |
| 8 | IP_MASK | Illegal Pointer Mask<br>When this bit is set, the FIFO controller masks the Status register’s IP bit from generating an error. |
| 9 | FAE_MASK | When this bit is set, the FIFO controller masks the Status Register’s FAE bit from generating an error. |
| 10 | RXW_MASK | When this bit is set, the FIFO controller masks the Status Register’s RXW bit from generating an error. (To help with backward compatibility, this bit is asserted at reset.) |
| 11 | UF_MASK | When this bit is set, the FIFO controller masks the Status Register’s UF bit from generating an error. |
| 12 | OF_MASK | When this bit is set, the FIFO controller masks the Status Register’s OF bit from generating an error. |
| 13:15 | Reserved | Unused. Software should write zero to these bits. |
| 16:31 | Reserved | Unused. Software should write zero to these bits. (R/W) |

### 10.3.3.1.13 Tx FIFO Alarm Register PCITFAR(RW)

MBAR + 0x384C

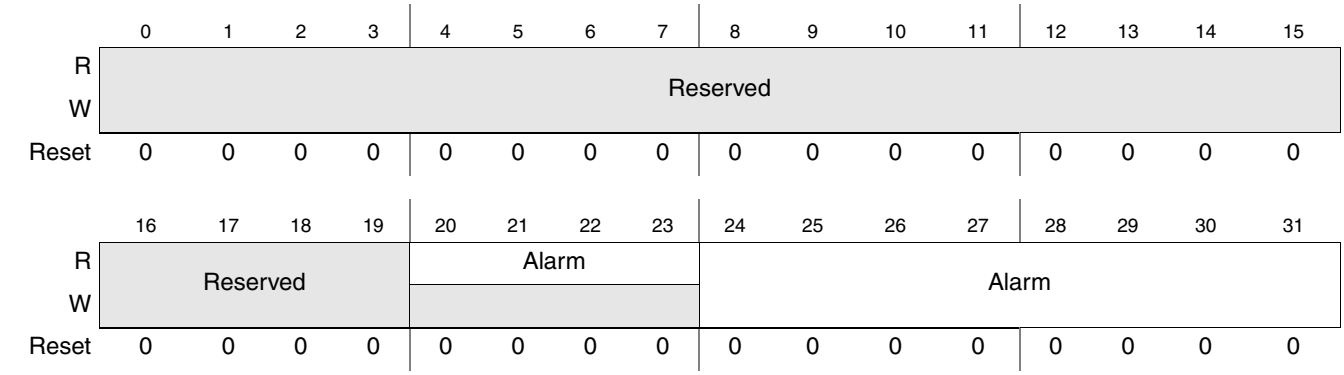



**Figure 10-32. Tx FIFO Alarm Register PCITFAR(RW)**

**Table 10-34. Tx FIFO Alarm Register PCITFAR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:19 | Reserved | Unused. Software should write zero to these bits. |
| 20:31 | Alarm | User writes these bits to set low level “watermark”, which is the point where FIFO asserts request for Multi-Channel DMA controller data filling. Value is in Bytes. For example, with Alarm = 32, alarm condition occurs when FIFO contains less than 32 Bytes. Once asserted, alarm does not negate until high level mark is reached, as specified by FIFO control register granularity (GR) bits.<br>**Note:** An Alarm setting less than the value of Max_Beats x 4 should be avoided. The transmit operation waits for the data to be stored in the FIFO before transmission onto the PCI bus. (e.g. A Max_setting of 0 represents eight beats (32-bits each) per transaction. The value of Alarm is in bytes. Ex: the value programmed to the Alarm register should be at least 0x20 (32 bytes) for the Multi-Channel DMA to continue to write enough data to complete at least one PCI burst.)<br>**Note:** TX PCI FIFO is 512 bytes deep. |

### 10.3.3.1.14 Tx FIFO Read Pointer Register PCITFRPR(RW)

MBAR + 0x3850

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | ReadPtr | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-33. Tx FIFO Read Pointer Register PCITFRPR(RW)**

**Table 10-35. Tx FIFO Read Pointer Register PCITFRPR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:19 | Reserved | Unused. Software should write zero to these bits. |
| 20:31 | ReadPtr | This value is maintained by FIFO hardware and is NOT normally written. It can be adjusted in special cases, but this disrupts data flow integrity. The value represents the Read address presented to the FIFO RAM. |

### 10.3.3.1.15 Tx FIFO Write Pointer Register PCITFWPR(RW)

MBAR + 0x3854

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | WritePtr | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-34. Tx FIFO Write Pointer Register PCITFWPR(RW)**

**Table 10-36. Tx FIFO Write Pointer Register PCITFWPR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:19 | Reserved | Unused bits. Software should write zero to these bits. |
| 20:31 | WritePtr | Value is maintained by FIFO hardware and is NOT normally written. It can be adjusted in special cases, but this disrupts data flow integrity. Value represents the Write address presented to the FIFO RAM. |

This marks the end of the PCI Multi-Channel DMA Transmit Interface description.

### 10.3.3.2 Multi-Channel DMA Receive Interface

PCI Rx is controlled by 13 32-bit registers. These registers are located at an offset from MBAR. Register addresses are relative to this offset.

#### 10.3.3.2.1 Rx Packet Size PCIRPSR(RW)

MBAR + 0x3880

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Packet_Size[31:16] | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Packet_Size[15:2] | | | | | | | | | | | | | | Packet_Siz[1:0] | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-35. Rx Packet Size PCIRPSR(RW)**

**Table 10-37. Rx Packet Size PCIRPSR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Packet_Size | The user writes this register with the number of bytes for Receive Controller to fetch over PCI. The two low bits are hardwired low; only 32-bit data transfers to the FIFO are allowed.<br>Writing to this register also completes a Restart Sequence as long as Master Enable bit, PCIRER[ME], is high and Reset Controller bit, PCIRER[RC], is low. |

#### 10.3.3.2.2 Rx Start Address PCIRSAR(RW)

MBAR + 0x3884

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Start_Add | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Start_Add | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-36. Rx Start Address PCIRSAR (RW)**

**Table 10-38. Rx Start Address PCIRSAR (RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Start_Add | The user writes this register with the desired Starting Address for the current packet. This is the address which will be first presented on the external PCI bus and then auto-incremented as necessary. This register will not increment as the PCI packet proceeds. |

### 10.3.3.2.3 Rx Transaction Control Register PCIRTCR(RW)

MBAR + 0x3888

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | PCI_cmnd | | | | Max_Retries | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | FB | R | Max_Beats | | | Reserved | | | W | Reserved | | | DI |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-37. Rx Transaction Control Register PCIRTCR(RW)**

**Table 10-39. Rx Transaction Control Register PCIRTCR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | Reserved | Unused. Software should write zero to these bits. |
| 4:7 | PCI_cmd | The user writes this field with the desired PCI command to present during the address phase of each PCI transaction. The default is Memory Read Multiple. This field is not checked for consistency and if written to an illegal value, unpredictable results will occur. If not using the default value, the user should write this register only once prior to any packet Restart. |
| 8:15 | Max_Retries | The user writes this field with the maximum number of retries to permit “per packet”. The retry counter is reset when the packet completes normally or is terminated by a master abort, target abort, or an abort due to exceeding the retry limit. A slow or malfunctioning Target might issue infinite disconnects and therefore permanently tie up the PCI bus.<br>A finite (0x01 to 0xff) Max_Retries value will detect this condition and generate an interrupt. Setting Max_Retries to 0x00 will not generate any interrupt. |
| 16:18 | Reserved | Unused. Software should write zero to these bits. |
| 19 | Full Burst (FB) | This is the Full Burst bit. If Full Burst is set, no check of the Receive Fifo emptiness is done and the PCI transaction is immediately started when Packet_Size register is written (and SCPCI RX gains the PCI bus).<br>The PCI transaction will continue with multiple data beats UNTIL THE FULL PACKET IS TRANSFERRED (up to 4G bytes). The Full Burst operation avoids latency time-out and will not relinquish the bus until all Packet Bytes are received.<br>**Note:** All FIFO checks (by scpci Rx) are disabled in this mode. It is up to the Multi-Channel DMA to keep the Rx FIFO from being overrun by the continuous incoming PCI burst data.<br>**Note:** It is recommended to use the Full Burst mode only for transactions where more than 32 Bytes should be received.<br>**Note:** Max_Beats must be set to 0. |
| 20 | Reserved | Unused. Software should write zero to this bit. |
| 21:23 | Max_Beats | The user writes this register with the desired number of PCI data beats to attempt on each PCI transaction. The default setting of 0 represents the maximum of eight beats per transaction. The receive controller will wait until sufficient space is in the Receive FIFO to support the indicated number of beats (Note: Each beat is four bytes). In the case that a packet is nearly complete and less than the Max_Beats number of bytes remain to complete the packet, the Receive Controller will issue single-beat transactions automatically until the packet is finished. |
| 24:26 | Reserved | Unused. Software should write zero to these bits. |

**Table 10-39. Rx Transaction Control Register PCIRTCR(RW) Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 27 | Word Transfer (W) | The user writes this register to disable the two high byte enables of the PCI bus during initiated read transactions. The default setting is 0, enable all 4 byte enables. |
| 28:30 | Reserved | Unused. Software should write zero to these bits. |
| 31 | Disable address Incrementing (DI) | The user writes this register to disable PCI address incrementing between transactions. The default setting is 0, increment address by 4 (4 byte data bus).<br>**Note:** This feature is recommended when reading from an external FIFO (having a fixed address). |

### 10.3.3.2.4 Rx Enables PCIRER(RW)

MBAR + 0x388C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | RC | RF | FE | CM | BE | Reserved | | ME | Reserved | | FEE | SE | RE | TAE | IAE | NE |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-38. Rx Enables PCIRER (RW)**

**Table 10-40. Rx Enables PCIRER (RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | Reset Controller (RC) | User writes this bit high to put Receive Controller in a reset state. Note that other register bits are not affected. This Reset is intended for recovery from an error condition or to reload the Start Address when Continuous mode is selected. This Reset bit does not prohibit register access but it must be negated in order to initiate a Restart sequence (i.e. writing the Packet_Size register). If it is used to reload a Start Address then the Start_Add register must be written prior to asserting this Reset bit. |
| 1 | Reset FIFO (RF) | The FIFO will be reset and flushed of any existing data when set high. The Reset Controller bit and the Reset FIFO bit operate independently, but clearly both must be low for normal operation. |
| 2 | FE | Flush enable. This is an important bit which causes a flush signal to be generated to the Receive FIFO Controller when the end of the current packet occurs. This Flush is necessary to insure that the Multi-Channel DMA will get all data left in the Receive FIFO. FE is active high. |
| 3 | Continuous mode (CM) | User writes this bit high to activate Continuous mode. In Continuous mode the Start_Add value is ignored at each packet restart and the PCI address is auto-incremented from one packet to the next. Also, the Packets_Done status byte will become active, indicating how many packets have been received since the last Reset Controller condition. If the Continuous bit is low, software is responsible for updating the Start_Add value at each packet Restart. |

**Table 10-40. Rx Enables PCIRER (RW) Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 4 | Bus error Enable (BE) | User writes this bit high to enable Bus Error indications. Section 10.3.3.2.9, "Rx Status PCIRSR(R/sw1)" for Bus Error descriptions. Normally this bit will be 0 since illegal Slave bus accesses are not destructive to register contents, although it may indicate broken software. Note that this bit does not affect interrupt generation. |
| 5:6 | Reserved | Unused. Software should write zero to these bits. |
| 7 | Master Enable (ME) | This is the Receive Controller master enable signal. User must write it high to enable operation. It can be toggled low to permit out-of-order register updates prior to generating a Restart sequence (in which case transmission will begin when Master Enable is written back high), but it should not be used as such in Continuous mode because it has the side effect of resetting the Packets_Done status counter. |
| 8:9 | Reserved | Unused. Software should write zero to these bits. |
| 10 | FIFO Error Enable (FEE) | User writes this bit high to enable CPU Interrupt generation in the case of FIFO error termination of a packet transmission. It may be desirable to mask CPU interrupts in the case that Multi-Channel DMA is controlling operation, but in such a case software should poll the status bits to prevent a possible lock-up condition. |
| 11 | System error Enable (SE) | User writes this bit high to enable CPU Interrupt generation in the case of system error termination of a packet transmission. It may be desirable to mask CPU interrupts in the case that Multi-Channel DMA is controlling operation, but in such a case software should be polling the status bits to prevent a possible lock-up condition. |
| 12 | Retry abort Enable (RE) | User writes this bit high to enable CPU Interrupt generation in the case of retry abort termination of a packet transmission. It may be desirable to mask CPU interrupts in the case that Multi-Channel DMA is controlling operation, but in such a case, software should poll the status bits to prevent a possible lock-up condition. |
| 13 | Target Abort Enable (TAE) | User writes this bit high to enable CPU Interrupt generation in the case of target abort termination of a packet transmission. It may be desirable to mask CPU interrupts in the case that Multi-Channel DMA is controlling operation, but in such a case software should poll the status bits to prevent a possible lock-up condition. |
| 14 | Initiator Abort error Enable (IAE) | User writes this bit high to enable CPU Interrupt generation in the case of initiator abort error termination of a packet transmission. It may be desirable to mask CPU interrupts in the case that Multi-Channel DMA is controlling operation, but in such a case software should poll the status bits to prevent a possible lock-up condition. |
| 15 | Normal termination Enable (NE) | User writes this bit high to enable CPU Interrupt generation at the conclusion of a normally terminated packet transmission. This may or may not be desirable depending on the nature of program control by Multi-Channel DMA or the processor core. |
| 16:31 | Reserved | Unused. Software should write zero to these bits. |

### 10.3.3.2.5 Rx Next Address PCIRNAR(R)

MBAR + 0x3890

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Next_Address | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Next_Address | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-39. Rx Next Address PCIRNAR(R)**

**Table 10-41. Rx Next Address PCIRNAR(R) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Next_Address | This status register contains the next (unread) PCI address and is updated at the successful completion of each PCI data beat. It represents a Byte address and is updated with a user-written Start_Add value when Start_Add is reloaded. This register is intended to be accurate even if an abnormal PCI bus termination occurs. |

### 10.3.3.2.6 Rx Last Word PCIRLWR(R)

MBAR + 0x3894

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Last_Word | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Last_Word | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-40. Rx Last Word PCIRLWR(R)**

**Table 10-42. Rx Last Word PCIRLWR(R) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Last_Word | This status register indicates the last 32-bit data fetched from the FIFO and is designed for the case in which an abnormal PCI termination has corrupted the integrity of the FIFO data (for that word). |

### 10.3.3.2.7 Rx Bytes Done Counts PCIRDCR(R)

MBAR + 0x3898

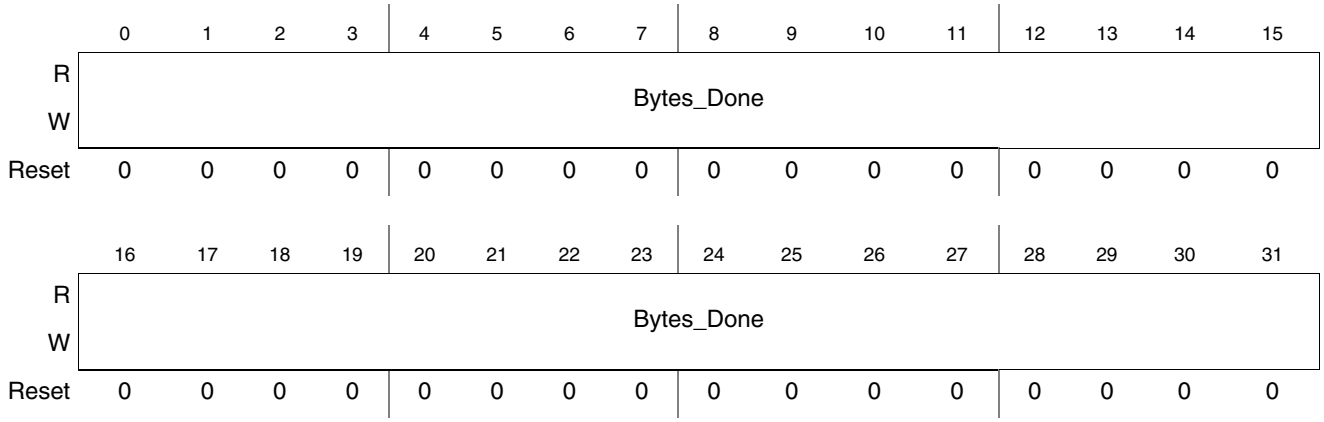



**Figure 10-41. Rx Bytes Done Counts PCIRDCR(R)**

**Table 10-43. Rx Bytes Done Counts PCIRDCR(R) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Bytes_Done | This status register indicates the number of Bytes received since the start of a packet. It is updated at the end of each successful PCI data beat. For normally terminated packets, the Bytes_Done value and the Packet_Size values are equal. If continuous mode is active, the Bytes_Done value reads 0 at the end of a successful packet and the Packets_Done field is incremented. |

### 10.3.3.2.8 Rx Packets Done Counts PCIRPDCR(R)

MBAR + 0x38A0

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Packets_Done | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Packets_Done | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-42. Rx Packets Done Counts PCIRPDCR(R)**

**Table 10-44. Rx Packets Done Counts PCIRPDCR(R) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | Packets_Done | This status register indicates the number of packets received. It is active only if continuous mode is in effect. If the following occurs, the counter is reset:<br>• Reset Controller bit, PCIRER[RC], is asserted (normal way to restart continuous mode)<br>• Master Enable bit, PCIRER[ME], is negated<br><br>In this way, master enable can be used to reset Packets_Done status without disturbing continuous mode addressing. At any point in time the total number of Bytes received can be calculated as:<br>(Packets_Done x Packet_Size) + Bytes_Done<br>This assumes Packet_Size is the same for all restart sequences. |

### 10.3.3.2.9 Rx Status PCIRSR(R/sw1)

MBAR + 0x389C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | NT | BE3 | BE2 | BE1 | FE | SE | RE | TA | IA |
| W | | | | | | | | rwc | rwc | rwc | rwc | rwc | rwc | rwc | rwc | rwc |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-43. Rx Status PCIRSR (R/sw1)**

**Table 10-45. Rx Status PCIRSR (R/sw1) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | Reserved | Unused. Software should write zero to these bits. |
| 7 | Normal Termination (NT) | This flag is set when any packet terminates normally. It is not set in the case of an abnormally terminated packet. It does not require clearing but will not clear until it is written to a one (in which case it will now read back as zero, i.e. negated).<br>>ALL THE FOLLOWING FLAG BITS OPERATE SIMILARLY< |
| 8 | Bus Error type 3 (BE3) | This flag is set whenever a Slave bus transaction attempts to write to a Read-Only register. This flag bit is set regardless of the Bus error Enable bit (BE). If software is polling this Byte and wishes to disregard this error it must mask this bit out. No corruption of the register bits occur for this (or any other) Bus Error case. |
| 9 | Bus Error type 2 (BE2) | This flag is set whenever a Slave bus transaction attempts to write to a Reserved register (an entire 32-bit register, not just a Reserved bit or byte). This flag bit is set regardless of the Bus error Enable bit (BE). If software is polling this Byte and wishes to disregard this error it must mask this bit out. |
| 10 | Bus Error type 1 (BE1) | This flag is set whenever a Slave bus transaction attempts to read a Reserved register (an entire 32-bit register, not just a Reserved bit or byte). This flag bit is set regardless of the Bus error Enable bit (BE). If software is polling this Byte and wishes to disregard this error it must mask this bit out. |
| 11 | FIFO Error (FE) | This flag is set whenever the Receive FIFO asserts its FIFO Error output. A CPU interrupt will be generated if the FIFO Error Enable (FEE) bit is set. The source of the error must be determined by reading the FIFO Error status register. Also, the error condition must be cleared at the FIFO prior to clearing this Sticky bit or this flag will continue to assert. |
| 12 | System Error (SE) | This flag is set in response to the Transmit Controller entering an illegal state. A CPU interrupt will be generated if the System error Enable (SE) bit is set. In normal operation this should never occur. The only recovery is to assert the Reset Controller bit, PCIRER[RC], and clear this flag. |
| 13 | Retry Error (RE) | This flag is set if Max_Retries is set to a finite value (0x01 to 0xff) and the PCI transaction has performed retries in excess of the setting. A CPU interrupt will be generated if the Retry error Enable (RE) bit is set. The retry counter is reset at the beginning of each transaction (i.e. it is not cumulative throughout a packet) and would generally indicate a broken or improperly accessed Target. |

**Table 10-45. Rx Status PCIRSR (R/sw1) Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 14 | Target Abort (TA) | This flag bit is set if the PCI controller has issued a Target Abort (which means the addressed PCI Target has signalled an Abort). A CPU interrupt will be generated if the Target Abort Enable (TAE) bit is set. It is up to application software to query the Target's status register and determine the source of the error. The coherency of the Receive FIFO data and the Receive Controller's status registers (Next_Address, Bytes_Done, etc.) should remain valid. |
| 15 | Initiator Abort (IA) | This flag bit is set if the PCI controller issues an Initiator Abort flag. This indicates that no Target responded but further status information can be read from the PCI Configuration interface. A CPU interrupt will be generated if the Initiator Abort error Enable (IAE) bit is set. The coherency of the Receive FIFO data and the Receive Controller's status registers (Next_Address, Bytes_Done, etc.) should remain valid. |
| 16:31 | Reserved | Unused. Software should write zero to these bits. |

## 10.3.3.2.10 Rx FIFO Data Register PCIRFDR(RW)

MBAR + 0x38C0

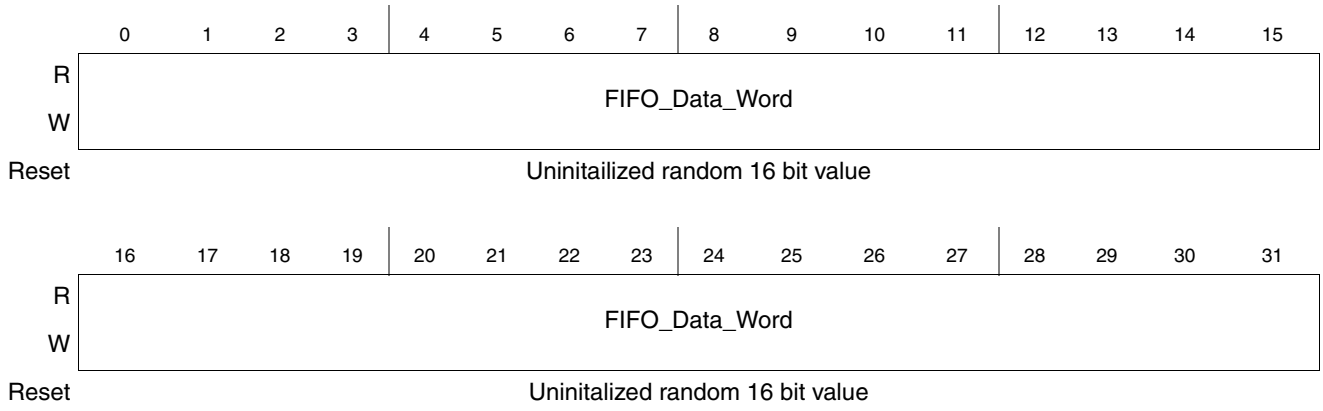

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
R
W
FIFO_Data_Word
Reset
Uninitailized random 16 bit value
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
R
W
FIFO_Data_Word
Reset
Uninitalized random 16 bit value

**Figure 10-44. Rx FIFO Data Register PCIRFDR(RW)**

**Table 10-46. Rx FIFO Data Register PCIRFDR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | FIFO_Data_Word | FIFO data port—Reading from this location "pops" data from the FIFO; writing "pushes" data into the FIFO. During normal operation the Multi-Channel DMA controller pops data here. The receive controller pushes data. Therefore, user programs should not write here. At power on reset an uninitialized random value is read at this register. A FIFO reset must be always performed before first accessing the FIFO.<br>**Note:** Only full 32-bit accesses are allowed. If all Byte enables are not asserted when accessing this location, FIFO data will be corrupted. |

### 10.3.3.2.11 Rx FIFO Status Register PCIRFSR(R/sw1)

MBAR + 0x38C4

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | RXW | UF | OF | FR | Full | Alarm | Empty |
| W | | | | | | | | | | rwc | rwc | rwc | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-45. Rx FIFO Status Register PCIRFSR(R/sw1)**

**Table 10-47. Rx FIFO Status Register PCIRFSR(R/sw1) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:8 | Reserved | Unused byte. Software should write zero to these bits. |
| 9 | Receive Wait Condition (RXW) | This flag bit indicates that the ipf_rcv bus is incurring wait states because there is not enough room in the FIFO to accept the data without causing overflow. This bit will cause the error outputs (fifoError, ipf_rcv_error, ipf_xmit_error) to assert unless the RXW_MASK bit in the FIFO Control register is set. Resetting the FIFO will clear this condition and the flag bit is cleared by writing a one to its bit position. |
| 10 | UnderFlow (UF) | This flag bit indicates that the read pointer has surpassed the write pointer. In other words the FIFO has been read beyond Empty. Resetting the FIFO will clear this condition and the flag bit is cleared by writing a one to its bit position. |
| 11 | OverFlow (OF) | This flag bit indicates that the write pointer has surpassed the read pointer. In other words the FIFO has been written beyond Full. Resetting the FIFO will clear this condition and the flag bit is cleared by writing a one to its bit position. |
| 12 | Frame Ready (FR) | The FIFO has a complete Frame of data ready for transmission. This module does not provide support for Data Framing applications, so this bit should be ignored. |
| 13 | Full | The FIFO is Full. This is not a sticky bit or error condition. The Full indication tracks with the state of the FIFO. |
| 14 | Alarm | When the FIFO pointer is at or above the Alarm “watermark”, as written by the user according to the Alarm and Control registers settings, the Alarm bit is asserted, thus automatically signalling to the DMA engine that the FIFO needs to be ‘emptied’. By writing a ‘1’ to this location software can enforce re-evaluation of the alarm condition. |
| 15 | Empty | The FIFO is empty. This is not a sticky bit or error condition. |
| 16:31 | Reserved | Unused. Software should write zero to these bits. |

### 10.3.3.2.12 Rx FIFO Control Register PCIRFCR(RW)

MBAR + 0x38C8

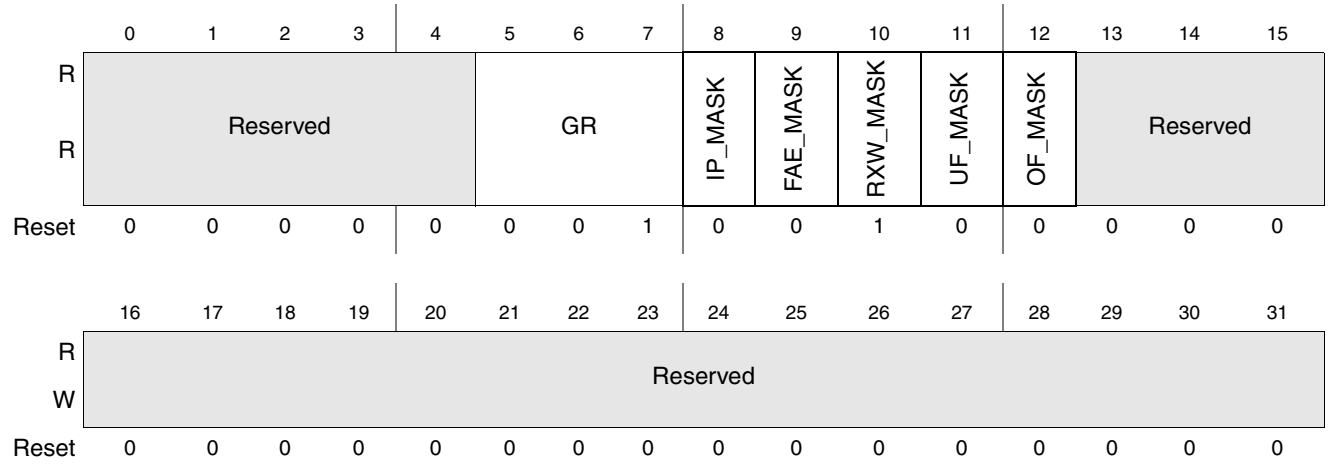



**Figure 10-46. Rx FIFO Control Register PCIRFCR(RW)**

**Table 10-48. Rx FIFO Control Register PCIRFCR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:4 | Reserved | Unused. Software shall write zero to these bits. (R/W) |
| 5:7 | Granularity (GR) | Granularity bits control high “watermark” point at which FIFO negates Alarm condition (i.e., request for data). It represents the number of free Bytes times 4.<br>**Note:** A granularity setting of zero should be avoided because it means the Alarm bit (and the Requestor signal) will not negate until the FIFO is completely full. The Multi-Channel DMA module may perform up to 2 additional data writes after the negation of a Requestor due to its internal pipelining.<br>**Note:** This field must be set to a value of 4 or higher. When the FIFO granularity is 0 - 3, read data can be corrupted with no error indication when the PCI controller simultaneously writes to the same location that the BestComm is reading from. The workaround is to use a FIFO granularity of 4 or greater. |
| 8 | IP_MASK | Illegal Pointer Mask<br>When this bit is set, the FIFO controller masks the Status register’s IP bit from generating an error. |
| 9 | FAE_MASK | When this bit is set, the FIFO controller masks the Status Register’s FAE bit from generating an error. |
| 10 | RXW_MASK | When this bit is set, the FIFO controller masks the Status Register’s RXW bit from generating an error. (To help with backward compatibility, this bit is asserted at reset.) |
| 11 | UF_MASK | When this bit is set, the FIFO controller masks the Status Register’s UF bit from generating an error. |
| 12 | OF_MASK | When this bit is set, the FIFO controller masks the Status Register’s OF bit from generating an error. |
| 13:15 | Reserved | Unused. Software should write zero to these bits. |
| 16:31 | Reserved | Unused. Software shall write zero to these bits. (R/W) |

### 10.3.3.2.13 Rx FIFO Alarm Register PCIRFAR(RW)

MBAR + 0x38CC

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| RESET | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | Alarm | | | | Alarm | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-47. Rx FIFO Alarm Register PCIRFAR(RW)**

**Table 10-49. Rx FIFO Alarm Register PCIRFAR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:19 | Reserved | Unused. Software should write zero to these bits. |
| 20:31 | Alarm [11:0] | User writes these bits to set the low level watermark, which is the point at which the FIFO asserts its request for data emptying to the Multi-Channel DMA controller. This value is in bytes. For example, with Alarm = 32, the alarm condition will occur when the FIFO has 32 or less free bytes in it. The alarm, once asserted, will not negate until the high level mark is reached, as specified by the Granularity bits in the Rx FIFO Control Register.<br>**Note:** The PCI RX FIFO is 512 bytes deep. |

### 10.3.3.2.14 Rx FIFO Read Pointer Register PCIRFRPR(RW)

MBAR + 0x38D0

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | ReadPtr | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-48. Rx FIFO Read Pointer Register PCIRFRPR(RW)**

**Table 10-50. Rx FIFO Read Pointer Register PCIRFRPR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:19 | Reserved | Unused. Software should write zero to these bits. |
| 20:31 | ReadPtr | This value is maintained by the FIFO hardware and is not normally written. It can be adjusted in special cases but will disrupt the integrity of the data flow. This value represents the Read address being presented to the FIFO RAM. |

### 10.3.3.2.15 Rx FIFO Write Pointer Register PCIRFWPR(RW)

MBAR + 0x38D4

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | WritePtr | | | | | | | | | | | |
| RESET | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 10-49. Rx FIFO Read Pointer Register PCIRFRPR(RW)**

**Table 10-51. Rx FIFO Read Pointer Register PCIRFRPR(RW) Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 12:19 | Reserved | Unused. Software should write zero to these bits. |
| 20:31 | WritePtr | This value is maintained by the FIFO hardware and is not normally written. It can be adjusted in special cases but will of course disrupt the integrity of the data flow. This value represents the Write address being presented to the FIFO RAM. |

This marks the end of the PCI Multi-Channel DMA Receive Interface description.

## 10.4 Functional Description

The MPC5200B PCI module provides both master and target PCI bus interfaces as shown in Figure 10-1. The internal *PCI master*, or *initiator*, interface is accessible by any XL bus master such as the processor core and also provides a DMA interface (for BestComm) through the Communication Sub-System, which can be accessed by the Multi-Channel DMA engine. The internal *PCI target* interface provides external PCI masters access into two memory windows of MPC5200B address space. PCI arbitration is handled external to this module, by the MPC5200B internal PCI arbiter.

**NOTE**

Only the internal PCI arbiter of the MPC5200B can be used as PCI arbiter for the PCI bus. An external PCI arbiter cannot be used.

The registers, described in Section 10.3, "Registers," control and provide information about these multiple interfaces. An additional Configuration interface allows internal access through the Slave bus(also referred to as IP bus) to the PCI Type 0 Configuration registers, which are accessible to both MPC5200B and external masters through the PCI bus.

The following sections describe the operation of the PCI module.

### 10.4.1 PCI Bus Protocol

This section will provide a simple overview of the PCI bus protocol, including some details of MPC5200B implementation. For details regarding PCI bus operation, refer to the *PCI Local Bus Specification, Revision 2.2*.

#### 10.4.1.1 PCI Bus Background

The PCI interface is synchronous and is best used for bursting data in large chunks. Its maximum theoretical bandwidth approaches 266 Megabytes per second for the 32-bit implementation running at 66MHz. A system will contain one device that is responsible for configuring all other devices on the bus upon reset. Each device has 256 bytes of configuration space that define individual requirements to the system controller. These registers are read and written through a "configuration access" command. A PCI transfer is started by the **master** and is directed toward a specific **target**. A provision is made for broadcasting to several targets through the "special command." Data is transferred through the use of memory and IO read and write commands.

**Table 10-52. PCI Command Encoding**

| C/BE[3:0] | Command Type |
|---|---|
| 0000 | Interrupt Acknowledge |
| 0001 | Special Cycle |
| 0010 | I/O Read |
| 0011 | I/O Write |
| 0100 | Reserved |
| 0101 | Reserved |

**Table 10-52. PCI Command Encoding (continued)**

| C/BE[3:0] | Command Type |
|---|---|
| 0110 | Memory Read |
| 0111 | Memory Write |
| 1000 | Reserved |
| 1001 | Reserved |
| 1010 | Configuration Read |
| 1011 | Configuration Write |
| 1100 | Memory Read Multiple |
| 1101 | Dual Address Cycle |
| 1110 | Memory Read Line |
| 1111 | Memory Write and Invalidate |

### 10.4.1.2 Basic Transfer Control

The basic PCI bus transfer mechanism is a burst. A burst is composed of an address phase followed by one or more data phases. Fundamentally, all PCI data transfers are controlled by three signals $\overline{\text{FRAME}}$, $\overline{\text{IRDY}}$, and $\overline{\text{TRDY}}$. An initiator asserts $\overline{\text{FRAME}}$ to indicate the beginning of a PCI bus transaction and negates $\overline{\text{FRAME}}$ to indicate the end of a PCI bus transaction. An initiator negates $\overline{\text{IRDY}}$ to force wait cycles. A target negates $\overline{\text{TRDY}}$ to force wait cycles.

The PCI bus is considered idle when both $\overline{\text{FRAME}}$ and $\overline{\text{IRDY}}$ are negated. The first clock cycle in which $\overline{\text{FRAME}}$ is asserted indicates the beginning of the address phase. The address and bus command code are transferred in that first cycle. The next cycle begins the first of one or more data phases. Data is transferred between initiator and target in each cycle that both $\overline{\text{IRDY}}$ and $\overline{\text{TRDY}}$ are asserted. Wait cycles may be inserted in a data phase by the initiator (by negating $\overline{\text{IRDY}}$) or by the target (by negating $\overline{\text{TRDY}}$).

Once an initiator has asserted $\overline{\text{IRDY}}$, it cannot change $\overline{\text{IRDY}}$ or $\overline{\text{FRAME}}$ until the current data phase completes regardless of the state of $\overline{\text{TRDY}}$. Once a target has asserted $\overline{\text{TRDY}}$ or $\overline{\text{STOP}}$, it cannot change $\overline{\text{DEVSEL}}$,$\overline{\text{TRDY}}$, or $\overline{\text{STOP}}$ until the current data phase completes. In simpler terms, once an initiator or target has committed to the data transfer, it cannot back out.

When the initiator intends to complete only one more data transfer (which could be immediately after the address phase), $\overline{\text{FRAME}}$ is negated and $\overline{\text{IRDY}}$ is asserted (or kept asserted) indicating the initiator is ready. After the target indicates the final data transfer (by asserting $\overline{\text{TRDY}}$), the PCI bus may return to the idle state (both $\overline{\text{FRAME}}$ and $\overline{\text{IRDY}}$ are negated).

**NOTE**

No Fast Back-to-Back transactions are supported by the MPC5200B.

### 10.4.1.3 PCI Transactions

The figures in this section show the basic “memory read” and “memory write” command transactions.

Figure 10-50 shows a PCI burst read transaction (2-beat). The signal $\overline{\text{FRAME}}$ is driven low to initiate the transfer. Cycle 1 is the address phase with valid address information driven on the AD bus and a PCI command driven on the $\overline{\text{C/BE}}$ bus. In cycle 2, the AD bus is in a turnaround cycle because of the read on a muxed bus. The byte enables, which are active low, are driven onto the $\overline{\text{C/BE}}$ bus in this clock. Any combination of byte enables can be asserted (none may be asserted). A target will respond to an address phase by driving the $\overline{\text{DEVSEL}}$ signal. The specification allows for four types of decode operations. The target can drive $\overline{\text{DEVSEL}}$ in 1, 2 or 3 clocks depending on whether the target is a fast, medium or slow decode device. A single device is allowed to drive $\overline{\text{DEVSEL}}$ should another agent fail to respond by the fourth clock. This is called “subtractive decoding” in PCI terminology.

A valid transfer occurs when both $\overline{\text{IRDY}}$ and $\overline{\text{TRDY}}$ are asserted. If either are negated during a data phase, it is considered a wait state. The target asserts a wait state in cycles 3 and 5 of Figure 10-50. A master indicates that the final data phase is to occur by negating $\overline{\text{FRAME}}$. The final data phase occurs in cycle 6. Another agent cannot start an access until cycle 8.

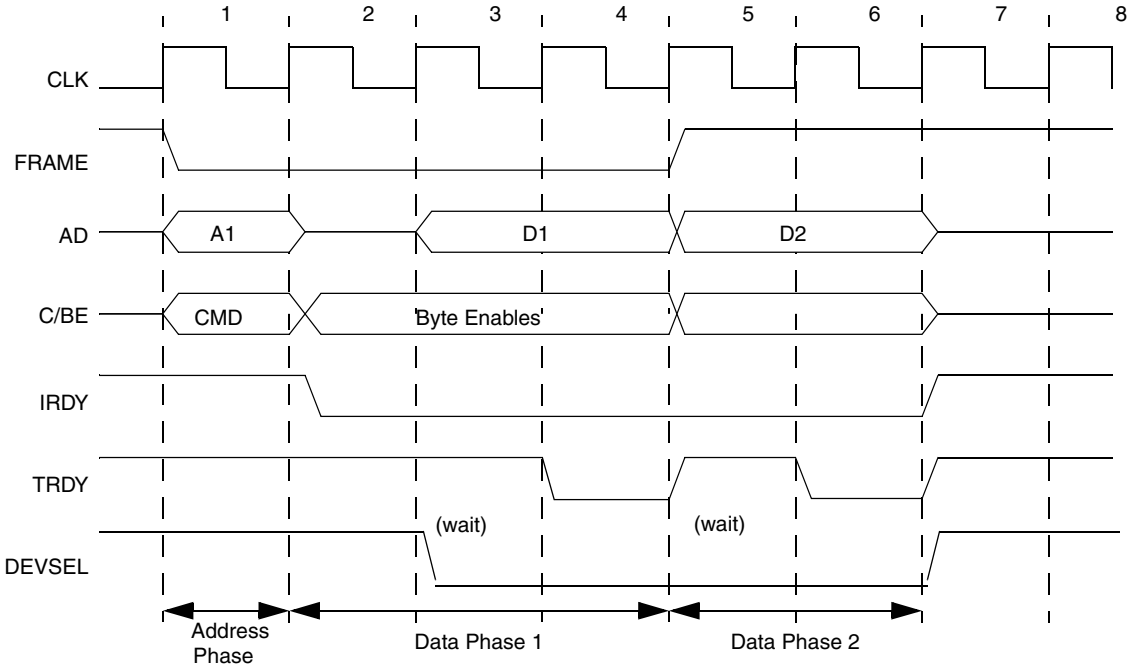



**Figure 10-50. PCI Read Terminated by Master**

Figure 10-51 shows a write cycle which is terminated by the target. In this diagram the target responds as a slow device, driving DEVSEL in cycle 4. The first data is transferred in cycle 4. The master inserts a wait state at cycle 5. The target indicates that it can accept only one more transfer by asserting both TRDY and STOP at the same time in cycle 5. The signal STOP must remain asserted until FRAME negates. The final data phase does not have to transfer data. If STOP and IRDY are both asserted while TRDY is negated, it is considered a target disconnect without a transfer. See the PCI specification for more details.

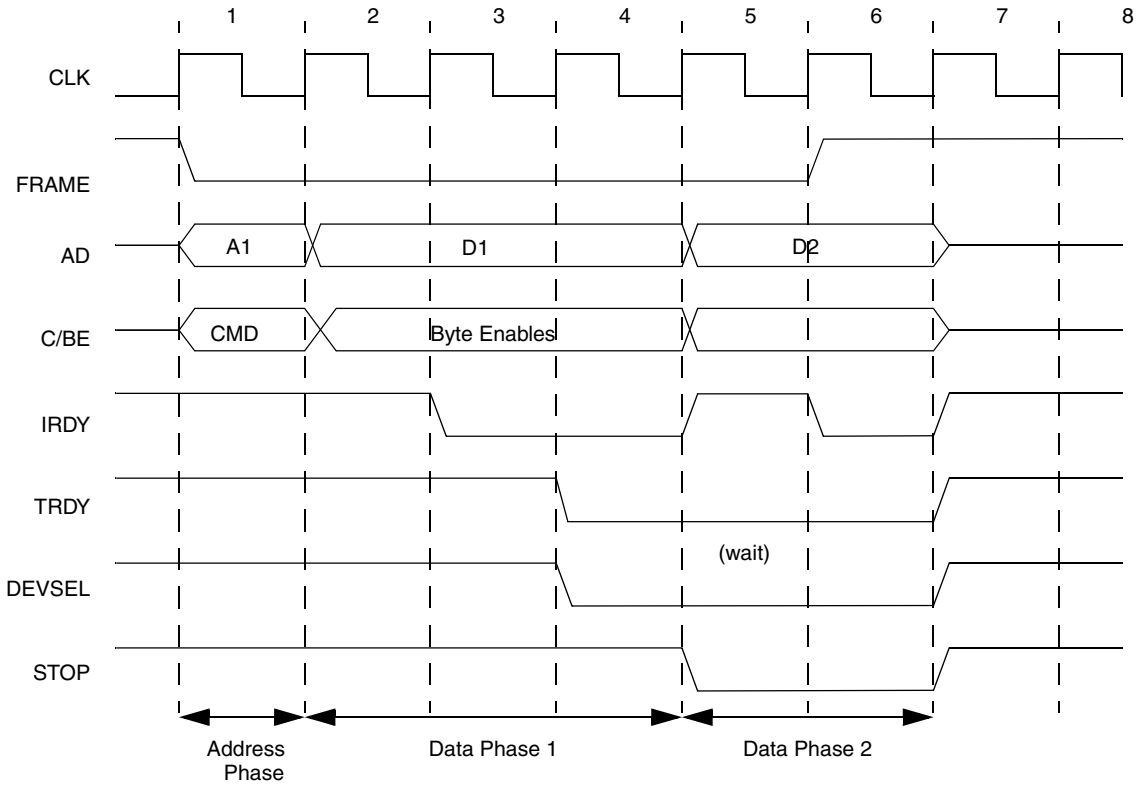



**Figure 10-51. PCI Write Terminated by Target**

### 10.4.1.4 PCI Bus Commands

PCI supports a number of different commands. These commands are presented by the initiator on the C/BE[3:0] lines during the address phase of a PCI transaction.

**Table 10-53. PCI Bus Commands**

| C/BE[3:0] | PCI Bus Command | MPC5200B Supports as Initiator | MPC5200B Supports as Target | Definition |
|---|---|---|---|---|
| 0000 | Interrupt acknowledge | Yes | No | The interrupt acknowledge command is a read (implicitly addressing an external interrupt controller). Only one device on the PCI bus should respond to the interrupt acknowledge command. |
| 0001 | Special Cycle | Yes | No | The Special Cycle command provides a mechanism to broadcast select messages to all devices on the PCI bus. |
| 0010 | I/O-read | Yes | No | The I/O-read command accesses agents mapped into the PCI I/O space. |
| 0011 | I/O-write | Yes | No | The I/O-write command accesses agents mapped into the PCI I/O space. |
| 0100 | Reserved | No | No | — |
| 0101 | Reserved | No | No | — |
| 0110 | Memory-read | Yes | Yes | The memory read command accesses agents mapped into PCI memory space. |
| 0111 | Memory-write | Yes | Yes | The memory write command accesses agents mapped into PCI memory space. |
| 1000 | Reserved | No | No | — |
| 1001 | Reserved | No | No | — |
| 1010 | Configuration read | Yes | Yes | The configuration read command accesses the 256 byte configuration space of a PCI agent. |
| 1011 | Configuration write | Yes | Yes | The configuration read command accesses the 256 byte configuration space of a PCI agent. |
| 1100 | Memory read multiple | Yes | Yes | For MPC5200B, the memory read multiple command functions the same as the memory read command. Cache line wrap is implemented when XL Bus is the transaction initiator and it also wraps. |
| 1101 | Dual address cycle | No | No | The dual address cycle command is used to transfer a 64-bit address (in two 32-bit address cycles) to 64-bit addressable devices. MPC5200B device does not respond to this command. |

**Table 10-53. PCI Bus Commands (continued)**

| C/BE[3:0] | PCI Bus Command | MPC5200B Supports as Initiator | MPC5200B Supports as Target | Definition |
|---|---|---|---|---|
| 1110 | Memory read line | Yes | Yes | The memory read line command indicates that an initiator is requesting the transfer of an entire cache line.For MPC5200B, the memory read line functions the same as the memory read command. Cache line wrap is not implemented. |
| 1111 | Memory write and invalidate | Yes (DMA access only) | Yes | The memory write and invalidate command indicates that an initiator is transferring an entire cache line, and, if this data is in any cacheable memory, that cache line needs to be invalidated. The memory write and invalidate functions the same as the memory write command. Cache line wrap is implemented.<br>Software must make sure that the cache line register and max_beats register are set to the same value and the packet size must be a multiple of the cache line size.<br>This instruction is supported only by the TX SCPCI initiator interface and when the MPC5200B acts as a target. |

Though MPC5200B supports many PCI commands as an initiator, the Communication Sub-System Initiator interface is intended to use PCI Memory Read, and Memory Write commands.

### 10.4.1.5 Addressing

PCI defines three physical address spaces: PCI memory space, PCI I/O space, and PCI configuration space. Address decoding on the PCI bus is performed by every device for every PCI transaction. Each agent is responsible for decoding its own address. PCI supports two types of address decoding: positive decoding and subtractive decoding. The address space which is accessed depends primarily on the type of PCI command that is used.

#### 10.4.1.5.1 Memory Space Addressing

For memory accesses, PCI defines two types of burst ordering controlled by the two low-order bits of the address: linear incrementing(AD[1:0] = 0b00) and cache wrap mode (AD[1:0] = 0b10). The other two AD[1:0] encodings (0b01 and 0b11) are reserved.

For linear incrementing mode, the memory address is encoded/decoded using AD[31:2]. Thereafter, the address is incremented by 4 bytes after each data phase completes until the transaction is terminated or completed (a 4 byte data width per data phase is implied). Note, the two low-order bits of the address are still included in all the parity calculations.

MPC5200B supports both linear incrementing and cache wrap mode as an initiator. For memory transactions, when an XL Bus burst transaction is wrapped, the cache wrap mode is automatically generated. For zero-word-aligned bursts and single-beat transactions, MPC5200B drives AD[1:0] to 0b00. As a target, the MPC5200B treats cache wrap mode as a reserved memory mode. MPC5200B will return the first beat of data and then signal a disconnect without data on the second data phase.

#### 10.4.1.5.2 I/O Space Addressing

For PCI I/O accesses, all 32 address signals are used to provide an address with granularity of a single byte. Once a target has claimed an I/O access, it must determine if it can complete the entire access as indicated by the byte enable signals. If all the selected bytes are not in the address range of the target, the entire access cannot complete. In this case, the target does not transfer any data, and terminates the transaction with a target-abort.

**Table 10-54. PCI I/O Space Byte Decoding**

| Access Size | AD[1:0] | C/BE[3:0] | Data |
|---|---|---|---|
| 8-bit | 00 | xxx0 | AD[7:0] |
| | 01 | xx01 | AD[15:8] |
| | 10 | x011 | AD[23:16] |
| | 11 | 0111 | AD[31:24] |
| 16-bit | 00 | xxx0 | AD[15:0] |
| | 01 | xx01 | AD[23:8] |
| | 10 | x011 | AD[31:16] |
| 24-bit | 00 | xxx0 | AD[23:0] |
| | 01 | xx01 | AD[31:8] |
| 32-bit | 00 | xxx0 | AD[31:0] |

#### 10.4.1.5.3 Configuration Space Addressing and Transactions

PCI supports two types of configuration accesses. Their primary difference is the format of the address on the AD[31:0] signals during the address phase. The two low-order bits of the address indicate the format used for the configuration address phase: type 0 (AD[1:0] = 0b00) or type 1 (AD[1:0] = 0b01). Both address formats identify a specific device and a specific configuration register for that device.

Type 0 configuration accesses are used to select a device on the local PCI bus. They do not propagate beyond the local PCI bus and are either claimed by a local device or terminated with a master-abort. Type 1 configuration accesses are used to target a device on a subordinate bus through a PCI-to-PCI bridge. Type 1 accesses are ignored by all targets except PCI-to-PCI bridges that pass the configuration request to another PCI bus.

When the controller initiates a configuration access on the PCI bus, it places the configuration address information on the AD bus and the configuration command on the $\overline{\text{C/BE}}$[3:0] bus. A Type 0 configuration transaction is indicated by setting AD[1:0] to 0b00 during the address phase. The bit pattern tells the community of devices on the PCI bus that the bridge that “owns” that bus has already performed the bus number comparison and verified that the request targets a device on its bus. Figure 10-52 shows the contents of the AD bus during the address phase of the Type 0 configuration access.

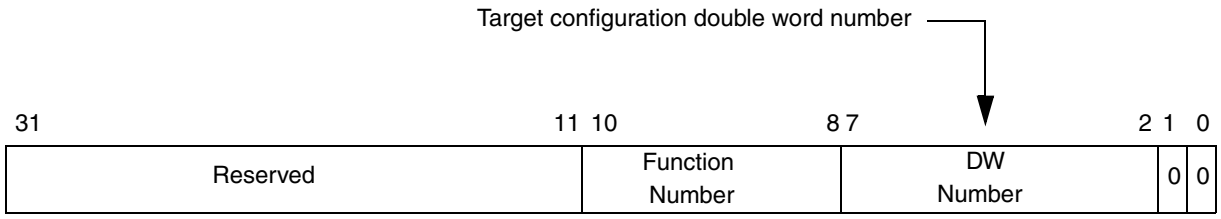



**Figure 10-52. Contents of the AD Bus During Address Phase of a Type 0 Configuration Transaction**

Address bits [10:8] identify the target function and bits AD[7:2] select one of the 64 configuration dwords within the target function's configuration space. For Type 0 configuration transactions, the target device's IDSEL pin must be asserted. The upper 21 address lines are commonly used as IDSELs since they are not used during the address phase of a type 0 configuration transaction.

If the target bus is a bus that is subordinate to the local PCI bus (bus 0), the configuration transaction is still initiated on bus 0, but indicates that none of the devices on this bus are the target of the transaction. Rather, only PCI-to-PCI bridges residing on the bus should pay attention to the transaction because it targets a device on a bus further out in the hierarchy beyond a PCI-to-PCI bridge that is attached to the local PCI bus (bus 0). This is accomplished by initiating a Type 1 configuration transaction (setting AD[1:0] to 01b during the address phase). This pattern instructs all functions other than PCI-to-PCI bridges that the transaction is not for any of them. Figure 10-53 illustrates the contents of the AD bus during the address phase of the Type 1 configuration access.

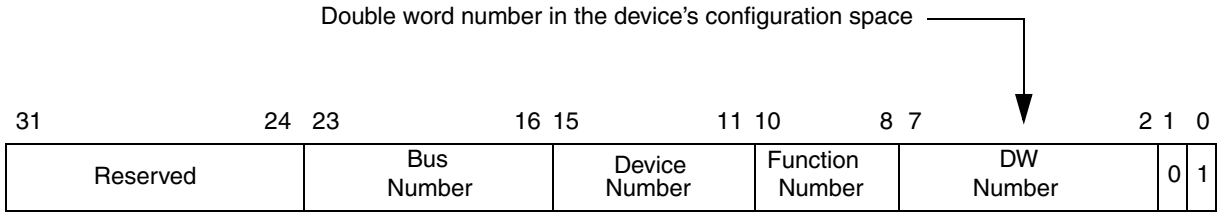



**Figure 10-53. Contents of the AD Bus During Address Phase of a Type 1 Configuration Transaction**

During the address phase of a Type 1 configuration access, the information on the AD bus if formatted as follows:

- AD[1:0] contain a 01b, identifying this as a Type 1 configuration access.
- AD[7:2] identifies one of 64 configuration dwords within the target devices's configuration space.
- AD[10:8] identifies one of the eight functions within the target physical device.
- AD[15:11] identifies one of 32 physical devices. This field is used by the bridge to select which device's IDSEL line to assert.
- AD[23:16] identifies one of 256 PCI buses in the system.
- AD[31:24] are reserved and are cleared to zero.

During a Type 1 configuration access, PCI devices ignore the state of their IDSEL inputs. When any PCI-to-PCI bridge latches a Type 1 configuration access (command = configuration read or write and AD[1:0] = 01b) on its primary side, it must determine whether the bus number field on the AD bus matches the number of its secondary bus or if it's within the range of its subordinate buses. If the bus number matches, it should claim and pass the configuration access onto its secondary bus as a Type 0 configuration access, decoding the device number to select one of the IDSEL lines. If the bus number isn't equal to its secondary bus, but is within the range of buses that are subordinate to the bridge, the bridge claims and passes that access through as a Type 1 access.

#### 10.4.1.5.4 Address Decoding

For positive address decoding, an address hits when the address on the address bus matches an assigned address range. Multiple devices on the same PCI bus may use positive address decoding, though there can not be any overlap in the assigned address ranges.

For subtractive address decoding, an address hits when the address on the address bus does not match any address range for any of the PCI devices on the bus. Only one device on a PCI bus may use subtractive address decoding, and its use is optional.

### 10.4.2 Initiator Arbitration

There are three possible internal initiator sources - CommBus Transmit, CommBus Receive, or the XL bus (from Internal System Arbiter). Custom interface logic arbitrates and provides mux select control for these sources to the PCI controller. Figure 10-54 illustrates the arbitration block connection.

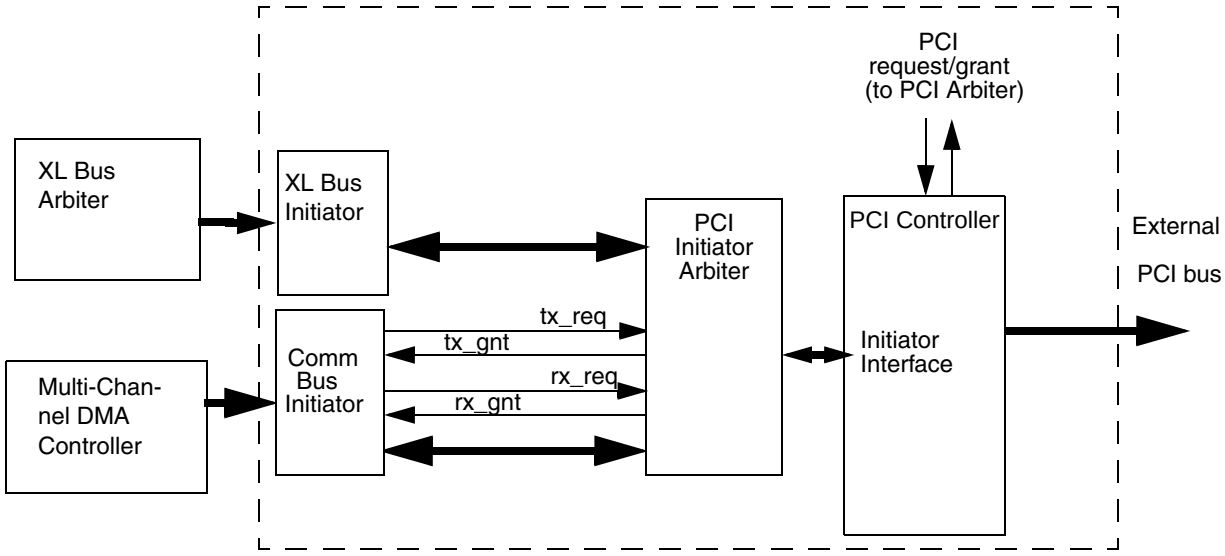



**Figure 10-54. Initiator Arbitration Block Diagram**

#### 10.4.2.1 Priority Scheme

The PCI Initiator arbiter uses the following fixed priority scheme.

1. XL bus Initiator
2. CommBus Transmit (Tx)
3. CommBus Receive (Rx) (lowest)

### 10.4.3 Configuration Interface

The PCI bus protocol requires the implementation of a standardized set of registers for most devices on the PCI bus. MPC5200B implements a Type 0 Configuration register set or header. They are described in Section 10.3.1, "PCI Controller Type 0 Configuration Space." These registers are primarily intended to be read or written by the PCI configuring master at initialization time through the PCI bus. MPC5200B provides internal access to these registers through a Slave bus interface. As with most MPC5200B registers, they are accessible by software in the address space at offsets of MBAR. Internal accesses to the Type 0 Configuration header do not require PCI arbitration when they are accessed as offsets of MBAR and are allowed to execute regardless of whether any write data is posted in the PCI Controller.

If MPC5200B is the configuring master, the Slave bus interface should be used to configure the PCI Controller. An external master would configure the PCI controller through the external PCI bus.

More information on the standard PCI Configuration register can be found in the PCI 2.2 specification.

### 10.4.4 XL bus Initiator Interface

The XL bus Initiator Interface provides access to the PCI bus for XL bus masters, primarily the processor core. This interface is accessed through three windows in MPC5200B address space set up by base address and base address mask registers (Initiator Window 0 Base/Translation Address Register PCIIW0BTAR(RW)). The base address registers must be enabled by setting their respective Enable bits in the Initiator Window Configuration Register PCIIWCR(RW). Accesses to this area are translated into PCI transactions on the PCI bus. See Section 10.6.2, Address Maps for examples on setting up address windows.

The particular type of PCI transaction generated is determined by the PCI configuration bits associated with the address window (PCIIWCR). For example, the user might set one window to do PCI memory read multiple accesses, one window for PCI I/O accesses, and the other window to do non-prefetchable (memory-mapped I/O) PCI memory accesses. Table 10-63 for command translation.

In addition to the configurable address window mapping logic, the register interface provides a Configuration Address Register, which provides the ability to generate Configuration, Interrupt Acknowledge and Special Cycles. External PCI devices should be configured through this interface. Section 10.4.4.2, "Configuration Mechanism" for configuration, interrupt acknowledge, and special cycle command support.

The PCI XL Bus Initiator interface supports all XL Bus transactions, including single-beat transfers and bursts (32 bytes). Single-beat 64-bit data transactions are automatically translated into 2-beats burst transfers on the PCI bus. Standard XL bus burst transactions are supported as well, however, buffering is

implemented to boost performance during writes and avoid deadlock scenario for all reads and memory writes. If the target for an XL bus read from PCI disconnects part way through the burst, MPC5200B may have to handle a local memory access from an alternate PCI master before the disconnected transfer can continue.

XL Bus initiator read requests are decoded into four types: PCI Memory, I/O, Configuration, and Interrupt Acknowledge. The PCI Controller must first gain access to the PCI bus before acknowledging the XL Bus read request. The specific timing of the address acknowledge is dependent upon the type of transfer.

When the XL bus requests burst data from PCI space, the data received from PCI is stored in a buffer until all requested data has been latched. The PCI Controller does not terminate the address tenure of the XL Bus transaction until all requested data is latched. This is because PCI targets are allowed to disconnect in the middle of a transfer, and the XL bus requires burst transfers to be atomic. If the PCI target disconnects in the middle of the data transfer and an alternate PCI master acquires the bus and initiates a local memory access, the Controller retries the internal read transaction on the XL bus. The PCI Controller continues to request mastership of the PCI bus until the original request is completed.

For example, if the XL bus initiates a burst read, and the PCI target disconnects after transferring the first half of the burst, MPC5200B re-arbitrates for the PCI bus, and when granted, initiates a new transaction with the address of the third beat of the burst (4-beat XL Bus bus bursts). If an alternate PCI master requests data from local memory while the PCI Controller is waiting for the PCI bus grant, the PCI controller retries the XL Bus bus transaction to allow the PCI-initiated transaction to complete and the read buffer will be emptied.

PCI critical-word-first (CWF) burst operation (i.e. cache line wrap burst) is supported and the 2-bit cache line wrap address mode is driven on the address bus when the XL Bus bus starts the burst at a non-zero-word-first address. Note that this option is only provided as a means to support memory targets that support cache-line wrap.

**NOTE**

A processor is not permitted to cache from any external memory targets residing on the PCI bus. This was allowed previously in the PCI spec. 2.1. The PCI spec. 2.2. took this requirements away.

XL bus writes are decoded into PCI memory, PCI I/O, PCI configuration, or special cycles. If the transaction decodes into an I/O, configuration, or special cycle, the write is connected. The PCI controller gains access to the PCI bus and successfully transfers the data before it asserts address acknowledge to the XL bus. If the address maps to PCI memory space, the XL Bus address tenure is immediately acknowledged and write data is posted.

A 32-byte buffer is used to post memory writes from XL Bus to PCI. Buffering minimizes the effect of the slower PCI bus on the higher-speed XL bus. It may contain single-beat XL Bus write transactions or a single burst. After the XL bus write data is latched internally, the bus is available for subsequent transactions without having to wait for the write to the PCI target to complete. If a subsequent XL Bus write request to the PCI bus comes in, the data transfer is delayed until all previous writes to the PCI bus are completed. Only when the write buffer is empty can burst data from the XL bus be posted.

### 10.4.4.1 Endian Translation

The PCI bus is inherently little endian in its byte ordering. The internal XLB bus, however, is big endian. XLB bus transactions are limited to 1, 2, 3, 4, 5, 6, 7, 8, or 32 byte (burst) transactions within the data bus byte lanes on any 32-bit address boundary for burst transfers. Table 10-55 shows the byte lane mapping between the two buses.

**Table 10-55. XLB bus to PCI Byte Lanes for Memory[1] Transactions**

| XL bus | | | | | | | | | | PCI Bus | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A [29:31] | TSIZ [0:2] | Data Bus Byte Lanes | | | | | | | | AD [2:0] | BE [3:0] | 31:24 | 23:16 | 15:8 | 7:0 |
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | |
| 000 | 001 | OP7 | — | — | — | — | — | — | — | 000 | 1110 | — | — | — | OP7 |
| 001 | 001 | — | OP7 | — | — | — | — | — | — | 000 | 1101 | — | — | OP7 | — |
| 010 | 001 | — | — | OP7 | — | — | — | — | — | 000 | 1011 | — | OP7 | — | — |
| 011 | 001 | — | — | — | OP7 | — | — | — | — | 000 | 0111 | OP7 | — | — | — |
| 100 | 001 | — | — | — | — | OP7 | — | — | — | 100 | 1110 | — | — | — | OP7 |
| 101 | 001 | — | — | — | — | — | OP7 | — | — | 100 | 1101 | — | — | OP7 | — |
| 110 | 001 | — | — | — | — | — | — | OP7 | — | 100 | 1011 | — | OP7 | — | — |
| 111 | 001 | — | — | — | — | — | — | — | OP7 | 100 | 0111 | OP7 | — | — | — |
| 000 | 010 | OP6 | OP7 | — | — | — | — | — | — | 000 | 1100 | — | — | OP7 | OP6 |
| 001 | 010 | — | OP6 | OP7 | — | — | — | — | — | 000 | 1001 | — | OP7 | OP6 | — |
| 010 | 010 | — | — | OP6 | OP7 | — | — | — | — | 000 | 0011 | OP7 | OP6 | — | — |
| 011 | 010 | — | — | — | OP6 | OP7 | — | — | — | 000 | 0111 | OP6 | — | — | — |
| | | | | | | | | | | 100 | 1110 | — | — | — | OP7 |
| 100 | 010 | — | — | — | — | OP6 | OP7 | — | — | 100 | 1100 | — | — | OP7 | OP6 |
| 101 | 010 | — | — | — | — | — | OP6 | OP7 | — | 100 | 1001 | — | OP7 | OP6 | — |
| 110 | 010 | — | — | — | — | — | — | OP6 | OP7 | 100 | 0011 | OP7 | OP6 | — | — |
| 000 | 011 | OP5 | OP6 | OP7 | — | — | — | — | — | 000 | 1000 | — | OP7 | OP6 | OP5 |
| 001 | 011 | — | OP5 | OP6 | OP7 | — | — | — | — | 000 | 0001 | OP7 | OP6 | OP5 | — |
| 010 | 011 | — | — | OP5 | OP6 | OP7 | — | — | — | 000 | 0011 | OP6 | OP5 | — | — |
| | | | | | | | | | | 100 | 1110 | — | — | — | OP7 |
| 011 | 011 | — | — | — | OP5 | OP6 | OP7 | — | — | 000 | 0111 | OP5 | — | — | — |
| | | | | | | | | | | 100 | 1100 | — | — | OP7 | OP6 |
| 100 | 011 | — | — | — | — | OP5 | OP6 | OP7 | — | 100 | 1000 | — | OP7 | OP6 | OP5 |
| 101 | 011 | — | — | — | — | — | OP5 | OP6 | OP7 | 00 | 0001 | OP7 | OP6 | OP5 | — |
| 000 | 100 | OP4 | OP5 | OP6 | OP7 | — | — | — | — | 00 | 0000 | OP7 | OP6 | OP5 | OP4 |

**Table 10-55. XLB bus to PCI Byte Lanes for Memory[1] Transactions (continued)**

| XL bus | | | | | | | | | | PCI Bus | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A [29:31] | TSIZ [0:2] | Data Bus Byte Lanes | | | | | | | | AD [2:0] | BE [3:0] | 31:24 | 23:16 | 15:8 | 7:0 |
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | |
| 001 | 100 | — | OP4 | OP5 | OP6 | OP7 | — | — | — | 000 | 0001 | OP6 | OP5 | OP4 | — |
| | | | | | | | | | | 100 | 1110 | — | — | — | OP7 |
| 010 | 100 | — | — | OP4 | OP5 | OP6 | OP7 | — | — | 000 | 0011 | OP5 | OP4 | — | — |
| | | | | | | | | | | 100 | 1100 | — | — | OP7 | OP6 |
| 011 | 100 | — | — | — | OP4 | OP5 | OP6 | OP7 | — | 000 | 0111 | OP4 | — | — | — |
| | | | | | | | | | | 100 | 1000 | — | OP7 | OP6 | OP5 |
| 100 | 100 | — | — | — | — | OP4 | OP5 | OP6 | OP7 | 100 | 0000 | OP7 | OP6 | OP5 | OP4 |
| 000 | 101 | OP3 | OP4 | OP5 | OP6 | OP7 | — | — | — | 000 | 0000 | OP6 | OP5 | OP4 | OP3 |
| | | | | | | | | | | 100 | 1110 | — | — | — | OP7 |
| 001 | 101 | — | OP3 | OP4 | OP5 | OP6 | OP7 | — | — | 000 | 0001 | OP5 | OP4 | OP3 | — |
| | | | | | | | | | | 100 | 1100 | — | — | OP7 | OP6 |
| 010 | 101 | — | — | OP3 | OP4 | OP5 | OP6 | OP7 | — | 000 | 0011 | OP4 | OP3 | — | — |
| | | | | | | | | | | 100 | 1000 | — | OP7 | OP6 | OP5 |
| 011 | 101 | — | — | — | OP3 | OP4 | OP5 | OP6 | OP7 | 000 | 0111 | OP3 | — | — | — |
| | | | | | | | | | | 100 | 0000 | OP7 | OP6 | OP5 | OP4 |
| 000 | 110 | OP2 | OP3 | OP4 | OP5 | OP6 | OP7 | — | — | 000 | 0000 | OP5 | OP4 | OP3 | OP2 |
| | | | | | | | | | | 100 | 1100 | — | — | OP7 | OP6 |
| 001 | 110 | — | OP2 | OP3 | OP4 | OP5 | OP6 | OP7 | — | 000 | 0001 | OP4 | OP3 | OP2 | — |
| | | | | | | | | | | 100 | 1000 | — | OP7 | OP6 | OP5 |
| 010 | 110 | — | — | OP2 | OP3 | OP4 | OP5 | OP6 | OP7 | 000 | 0011 | OP3 | OP2 | — | — |
| | | | | | | | | | | 100 | 0000 | OP7 | OP6 | OP5 | OP4 |
| 000 | 111 | OP1 | OP2 | OP3 | OP4 | OP5 | OP6 | OP7 | — | 000 | 0000 | OP4 | OP3 | OP2 | OP1 |
| | | | | | | | | | | 100 | 1000 | — | OP7 | OP6 | OP5 |
| 001 | 111 | — | OP1 | OP2 | OP3 | OP4 | OP5 | OP6 | OP7 | 000 | 0001 | OP3 | OP2 | OP1 | — |
| | | | | | | | | | | 100 | 0000 | OP7 | OP6 | OP5 | OP4 |
| 000 | 000 | OP0 | OP1 | OP2 | OP3 | OP4 | OP5 | OP6 | OP7 | 000 | 0000 | OP3 | OP2 | OP1 | OP0 |
| | | | | | | | | | | 100 | 0000 | OP7 | OP6 | OP5 | OP4 |

[1] The byte lane translation will be similar for other types of transactions. However, the PCI address may be different as explained in Section 10.4.1.5, “Addressing.”

### 10.4.4.2 Configuration Mechanism

In order to support both Type 0 and Type 1 configuration transactions, MPC5200B provides the 32 bit Configuration Address Register (CAR), located at module address 0x1F8. The register specifies the target PCI bus, device, function, and configuration register to be accessed. A read or a write to the MPC5200B window defined as PCI I/O space, in PCIIWCR, causes the host bridge to translate the access into a PCI configuration cycle if the enable bit in the Configuration Address Register is set and the device number does not equal 0b1_1111. For space to be defined as I/O space, the accessed space (one of the initiator Windows) must be programmed as I/O, not memory. Section 10.3.2.8, "Initiator Window Configuration Register PCIIWCR(RW)."

The format of the Configuration Address Register is shown in Section 10.3.2.12, "Configuration Address Register PCICAR(RW)." When MPC5200B detects an access to an I/O Window, it checks the enable flag and the device number in the Configuration Address Register. If the enable bit is set, and the device number is not 0b1_1111, the MPC5200B performs a configuration cycle translation function and runs a configuration read or configuration write transaction on the PCI bus. The device number 0b1_1111 is used for performing interrupt acknowledge and Special Cycle transactions. See Section 10.4.4.2.3, "Interrupt Acknowledge Transactions" and Section 10.4.4.2.4, "Special Cycle Transactions" for more information. If the bus number corresponds to the local PCI bus (bus number = 0x00), a Type 0 configuration cycle transaction is performed. If the bus number indicates a remote PCI bus, MPC5200B performs a Type 1 configuration cycle translation. If the enable bit is not set, the access to the Configuration Window is passed through to the PCI bus as a I/O space transaction at the internal address (window translation applies).

Note that the PCI data byte enables ($\overline{\text{C/BE[3:0]}}$) are determined by the size access to the Window.

#### 10.4.4.2.1 Type 0 Configuration Translation

Figure 10-55 shows the Type 0 translation function performed on the contents of the Configuration Address Register to the AD[31:0] signals on the PCI bus during the address phase of the configuration cycle (only applies when the Enable bit in the Configuration Address Register is set).

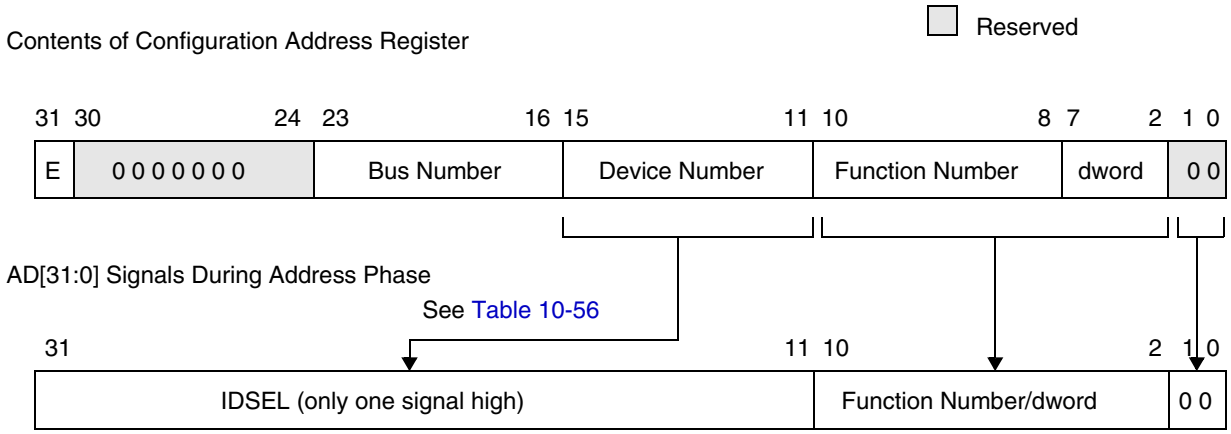



**Figure 10-55. Type 0 Configuration Translation**

For Type 0 configuration cycles, MPC5200B translates the device number field of the Configuration Address Register into a unique IDSEL line shown in Table 10-56. (allows for 21 different devices).

**Table 10-56. Type 0 Configuration Device Number to IDSEL Translation**

| Device Number | | IDSEL |
|---|---|---|
| Binary | Decimal | |
| 0b0_0000-0b0_1001 | 0-9 | - |
| 0b0_1010 | 10 | AD31 |
| 0b0_1011 | 11 | AD11 |
| 0b0_1100 | 12 | AD12 |
| 0b0_1101 | 13 | AD13 |
| 0b0_1110 | 14 | AD14 |
| 0b0_1111 | 15 | AD15 |
| 0b1_0000 | 16 | AD16 |
| 0b1_0001 | 17 | AD17 |
| 0b1_0010 | 18 | AD18 |
| 0b1_0011 | 19 | AD19 |
| 0b1_0100 | 20 | AD20 |
| 0b1_0101 | 21 | AD21 |
| 0b1_0110 | 22 | AD22 |
| 0b1_0111 | 23 | AD23 |
| 0b1_1000 | 24 | AD24 |
| 0b1_1001 | 25 | AD25 |
| 0b1_1010 | 26 | AD26 |
| 0b1_1011 | 27 | AD27 |
| 0b1_1100 | 28 | AD28 |
| 0b1_1101 | 29 | AD29 |
| 0b1_1110 | 30 | AD30 |
| 0b1_1111 | 31 | - |

**Note:** Device numbers 0b0_0000 to 0b0_1001 are reserved. Programming to these values and issuing a configuration transaction will result in a PCI configuration cycle with AD31-AD11 driven low.

MPC5200B can issue PCI configuration transactions to itself. A Type 0 configuration initiated by MPC5200B can access its own configuration space by asserting its IDSEL input signal. This is the only way MPC5200B can clear its own status register bits (read-write-clear).

For Type 0 translations, the function number and dword fields are copied without modification onto the AD[10:2] signals and AD[1:0] are driven low during the address phase.

#### 10.4.4.2.2 Type 1 Configuration Translation

For Type 1 translations, the 30 high-order bits of the Configuration Address Register are copied without modification onto the AD[31:2] signals during the address phase. The AD[1:0] signals are driven to 0b01 during the address phase to indicate a Type 1 configuration cycle.

#### 10.4.4.2.3 Interrupt Acknowledge Transactions

When MPC5200B detects a **read** from an I/O-defined Window (Section 10.3.2.8, “Initiator Window Configuration Register PCIIWCR(RW)”), it checks the enable flag, bus number, and the device number in the Configuration Address Register (Section 10.3.2.12, “Configuration Address Register PCICAR(RW)”). If the enable bit is set, the bus number corresponds to the local PCI bus (bus number = 0x00), and the device number is all 1’s (device number = 0b1_1111), then an interrupt acknowledge transaction is initiated. If the bus number indicates a subordinate PCI bus (bus number != 0x00), a Type 1 configuration cycle is initiated, similar to any other configuration cycle for which the bus number does not match. The function number and dword values are ignored.

The interrupt acknowledge command (0b0000) is driven on the $\overline{\text{C/BE[3:0]}}$ signals and the address bus is driven with a stable pattern during the address phase, but a valid address is not driven. The address of the target device during an interrupt acknowledge is implicit in the command type. Only the system interrupt controller on the PCI bus should respond to the interrupt acknowledge and return the interrupt vector on the data bus during the data phase. The size of the interrupt vector returned is indicated by the value driven on the $\overline{\text{C/BE[3:0]}}$ signals.

#### 10.4.4.2.4 Special Cycle Transactions

When the MPC5200B detects a **write** to an I/O-defined Window (Section 10.3.2.8, “Initiator Window Configuration Register PCIIWCR(RW)”), it checks the enable flag, bus number, and the device number in the Configuration Address Register (Section 10.3.2.12, “Configuration Address Register PCICAR(RW)”). If the enable bit is set, the bus number corresponds to the local PCI bus (bus number = 0x00), and the device number is all 1’s (device number = 0b1_1111), then a Special Cycle transaction is initiated. If the bus number indicates a subordinate PCI bus (bus number != 0x00), a Type 1 configuration cycle is initiated, similar to any other configuration cycle for which the bus number does not match. The function number and dword values are ignored.

The Special Cycle command (0b0001) is driven on the $\overline{\text{C/BE[3:0]}}$ signals and the address bus is driven with a stable pattern during the address phase, but contains no valid address information. The Special Cycle command contains no explicit destination address, but broadcast to all agents on the same bus segment. Each receiving agent must determine whether the message is applicable to it. PCI agent will never assert $\overline{\text{DEVSEL}}$ in response to a Special Cycle command. Master Abort is the normal termination

for a Special Cycle and no errors are reported for this case of Master Abort termination. This command is basically a broadcast to all agents, and interested agents accept the command and process the request.

**NOTE**

Special Cycle commands do not cross PCI-to-PCI bridges. If a master wants to generate a Special Cycle command on a specific bus in the hierarchy that is not its local bus, it must use a Type 1 configuration write command to do so. Type 1 configuration write commands can traverse PCI-to-PCI bridges in both directions for the purpose of generating Special Cycle commands on any bus in the hierarchy and are restricted to a single data phase in length. However, the master must know the specific bus on which it desires to generate the Special Cycle command and cannot simply do a broadcast to one bus and expect it to propagate to all buses.

During the data phase, AD[31:0] contain the Special Cycle message and an optional data field. The Special Cycle message is encoded on the 16 least significant bits (AD[15:0]) and the optional data field is encoded on the most significant bits (AD[31:16]). The Special Cycle message encodings are assigned by the PCI SIG Steering Committee. The current list of defined encodings are provided in Table 10-57.

**Table 10-57. Special Cycle Message Encodings**

| AD[15:0] | Message |
|---|---|
| 0x0000 | SHUTDOWN |
| 0x0001 | HALT |
| 0x0002 | x86 architecture-specific |
| 0x0003-0xFFFF | reserved |

### 10.4.4.3 Transaction Termination

If the PCI cycle Master Aborts, interface will return 0xFFFFFFFF as read data, but complete without error. It will issue an interrupt to the internal interrupt controller if enabled.

For abnormal transaction termination during an XL bus-initiated transaction (unsupported transfer types, retry limit reached, or target abort), an error is generated. It will issue an interrupt to the MPC5200B Interrupt controller if such interrupts are enabled.

Transfers that cross the 32-bit boundary (greater than 4 bytes) to a PCI non-memory address range result in a transfer error. The space is defined as non-memory if the IO/M# configuration bit associated with that window is programmed “0”.

**Table 10-58. Unsupported XL Bus Transfers**

| XL Bus Transaction | PCI Address Space |
|---|---|
| Burst (32-byte) | Nonmemory |
| > 4 byte Single Beat | Nonmemory |
| 4 byte Single Beat at a[29:31] 001, 010, or 011 | Nonmemory |
| 3 byte Single Beat at a[29:31] 010 or 011 | Nonmemory |
| 2 byte Single Beat at a[29:31] 011 | Nonmemory |

### 10.4.5 XL bus Target Interface

- The target interface can issue target abort, target retry, and target disconnect terminations.
- The target interface does NOT support fast back-to-back cycles.
- No support of dual address cycles as a PCI target.
- Target transactions are not snooped by the processor.
- Medium device selection timing
- Three 32-byte buffers enhance data throughput.

The XL Bus Target Interface provides access for external PCI masters to two windows of MPC5200B address space. Target Base Address Translation Registers 0 and 1 allow the user to map PCI address hits on MPC5200B PCI Base Address Registers to areas in the internal address space. All of these registers must be enabled for this interface to operate.

Upon detection of a PCI address phase, the PCI controller decodes the address and bus command to determine if the transaction is for local memory (BAR0 or BAR1hit). If the transaction falls within MPC5200B PCI space (a PCI memory space *only*), the PCI Controller target interface asserts $\overline{\text{DEVSEL}}$, latches the address, decodes the PCI bus command, and forwards them to the internal control unit. On writes, data is forwarded along with the byte enables to the internal gasket. On reads, four bytes of data are provided to the PCI bus and the byte enables determine which byte lanes contain meaningful data. If no byte enables are asserted, MPC5200B completes a read access with valid data and completes a write access by discarding the data internally. All target transactions will be translated into XL bus master transactions.

There are two address translation registers that must be initialized before data transfer can begin. These address registers correspond to BAR0 and BAR1 in MPC5200B PCI Type 00h Configuration space register (PCI space). When there is a hit on MPC5200B PCI base address ranges (0 or 1), the upper bits of the address are written over by this register value to address some space in MPC5200B. One 256Kbyte base address range (BAR0) maps to non-prefetchable local memory and one 1Gbyte range (BAR1) targeted to prefetchable memory.

#### 10.4.5.1 Reads from Local Memory

MPC5200B can provide continuous data to a PCI master using two 32-byte buffers. The PCI controller bursts reads internally at each 32-byte PCI address boundary. The data is stored in the first 32-byte buffer until either the PCI master flushes the data or the transaction terminates ($\overline{\text{FRAME}}$ deasserts). For prefetchable memory (BAR1 space), the next line can be fetched from memory in anticipation of the next PCI request (speculative read) and stored in the second buffer. Prefetching is performed for BAR1-addressed transactions if the PCI command is a Memory-Read-Multiple or the prefetch bit is set in the Target Control Register PCITCR(RW).

### 10.4.5.2 Local Memory Writes

A 32-byte write buffer is implemented to improve data throughput. This allows a write operation to be "*posted*", that is to successfully complete even when the PCI internal controller is requesting access to the local memory. In other words, data is latched while waiting for internal access to local memory to complete. While PCI burst transactions are accepted, writes are sent out on the internal bus as single-beat.

**NOTE**

Before a read from XL Bus to PCI or PCI to XL Bus can complete, all posted writes are flushed.

If the PCI controller aborts the transaction in the middle of PCI burst due to internal conflicts, the external master recognizes some of the data as transferred. (Subsequent transfers of a burst will be aborted on PCI bus). The external PCI master must query the "Target abort signalled" bit in the PCI Type 00h configuration status register to determine if a target abort occurred.

### 10.4.5.3 Data Translation

The XL bus supports misaligned operations, however, it is strongly recommended that software attempt to transfer contiguous code and data where possible. Non-contiguous transfers degrade performance.

PCI-to-XL Bus transaction data translation is shown in Table 10-59 and Table 10-60.

**Table 10-59. Aligned PCI to XL Bus Transfers**

| PCI Bus | | | | | | XL bus | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BE [3:0] | AD[2:0] | 31:24 | 23:16 | 15:8 | 7:0 | A[29:31] | Data Bus Byte Lanes | | | | | | | |
| | | | | | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1110 | 000 | | | | OP3 | 000 | OP3 | | | | | | | |
| 1101 | 000 | | | OP3 | | 001 | | OP3 | | | | | | |
| 1011 | 000 | | OP3 | | | 010 | | | OP3 | | | | | |
| 0111 | 000 | OP3 | | | | 011 | | | | OP3 | | | | |
| 1110 | 100 | | | | OP3 | 100 | | | | | OP3 | | | |
| 1101 | 100 | | | OP3 | | 101 | | | | | | OP3 | | |
| 1011 | 100 | | OP3 | | | 110 | | | | | | | OP3 | |
| 0111 | 100 | OP3 | | | | 111 | | | | | | | | OP3 |
| 1100 | 000 | | | OP3 | OP2 | 000 | OP2 | OP3 | | | | | | |
| 1001 | 000 | | OP3 | OP2 | | 001 | | OP2 | OP3 | | | | | |
| 0011 | 000 | OP3 | OP2 | | | 010 | | | OP2 | OP3 | | | | |
| 1100 | 100 | | | OP3 | OP2 | 100 | | | | | OP2 | OP3 | | |
| 1001 | 100 | | OP3 | OP2 | | 101 | | | | | | OP2 | OP3 | |
| 0011 | 100 | OP3 | OP2 | | | 110 | | | | | | | OP2 | OP3 |
| 1000 | 000 | | OP3 | OP2 | OP1 | 000 | OP1 | OP2 | OP3 | | | | | |
| 0001 | 000 | OP3 | OP2 | OP1 | | 000 | | OP1 | OP2 | OP3 | | | | |
| 1000 | 100 | | OP3 | OP2 | OP1 | 100 | | | | | OP1 | OP2 | OP3 | |

**Table 10-59. Aligned PCI to XL Bus Transfers (continued)**

| PCI Bus | | | | | | XL bus | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BE [3:0] | AD[2:0] | 31:24 | 23:16 | 15:8 | 7:0 | A[29:31] | Data Bus Byte Lanes | | | | | | | |
| | | | | | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0001 | 100 | OP3 | OP2 | OP1 | | 101 | | | | | | OP1 | OP2 | OP3 |
| 0000 | 000 | OP3 | OP2 | OP1 | OP0 | 000 | OP0 | OP1 | OP2 | OP3 | | | | |
| 0000 | 100 | OP3 | OP2 | OP1 | OP0 | 100 | | | | | OP0 | OP1 | OP2 | OP3 |

**Table 10-60. Non-contiguous PCI to XL Bus Transfers (requires two XL Bus bus accesses)**

| PCI Bus | | | | | | XL bus | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BE [3:0] | AD[2:0] | 31:24 | 23:16 | 15:8 | 7:0 | A[29:31] | Data Bus Byte Lanes | | | | | | | |
| | | | | | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1010 | 000 | | OP3 | | OP2 | 000 | OP2 | | | | | | | |
| | | | | | | 010 | | | OP3 | | | | | |
| 1010 | 100 | | OP3 | | OP2 | 100 | | | | | OP2 | | | |
| | | | | | | 110 | | | | | | | OP3 | |
| 0110 | 000 | OP3 | | | OP2 | 000 | OP2 | | | | | | | |
| | | | | | | 011 | | | | OP3 | | | | |
| 0110 | 100 | OP3 | | | OP2 | 100 | | | | | OP2 | | | |
| | | | | | | 111 | | | | | | | | OP3 |
| 0101 | 000 | OP3 | | OP2 | | 001 | | OP2 | | | | | | |
| | | | | | | 011 | | | | OP3 | | | | |
| 0101 | 100 | OP3 | | OP2 | | 101 | | | | | | OP2 | | |
| | | | | | | 111 | | | | | | | | OP3 |
| 0010 | 000 | OP3 | OP2 | | OP1 | 000 | OP1 | | | | | | | |
| | | | | | | 010 | | | OP2 | OP3 | | | | |
| 0010 | 100 | OP3 | OP2 | | OP1 | 100 | | | | | OP1 | | | |
| | | | | | | 110 | | | | | | | OP2 | OP3 |
| 0100 | 000 | OP3 | | OP2 | OP1 | 000 | OP1 | OP2 | | | | | | |
| | | | | | | 011 | | | | OP3 | | | | |
| 0100 | 100 | OP3 | | OP2 | OP1 | 100 | | | | | OP1 | OP2 | | |
| | | | | | | 111 | | | | | | | | OP3 |

#### 10.4.5.4 Target Abort

A target abort will occur if the PCI address falls within a base address window (BAR0 or BAR1) that has not been enabled. See Section 10.3.2.2, “Target Base Address Translation Register 0 PCITBATR0(RW)” and Section 10.3.2.3, “Target Base Address Translation Register 1 PCITBATR1(RW).”

#### 10.4.5.5 Latrule Disable

The latrule disable bit in the interface control register, Section 10.3.2.4, “Target Control Register PCITCR(RW),” prevents the PCI controller from automatically disconnecting a target transaction due to the PCI 16/8 clock rule. With this bit set, it is possible to hang the PCI bus if the internal bus does not complete the data transfer.

### 10.4.6 Communication Sub-System Initiator Interface

This interface provides for high-speed, autonomous DMA transactions to PCI with the PCI Controller operating as a standard Communication Sub-System peripheral. Full duplex operation is supported and direct XL bus transactions can also be interleaved while CommBus transactions are in progress. Internal arbitration will occur continuously to support transaction interleaving. (See Section 10.4.2, “Initiator Arbitration.”) Multi-Channel DMA operation operates independently of the XL bus. Non-PCI transactions on the XL bus will have 100% bandwidth available to them during PCI Multi-Channel DMA activities. In general, this block will be used by functions in the Multi-Channel DMA API.

The Communication Sub-System Initiator Interface consists of Receive and Transmit FIFOs, integrated as separate Multi-Channel DMA peripherals. Therefore, it is generally controlled by the Multi-Channel DMA controller through a pre-described program loop. As with all Communication Sub-System peripherals, it can be accessed and controlled directly through the Slave bus interface if desired, but this path does not generally lend itself to high throughput.

The Transmit and Receive FIFOs are 512 bytes deep and support PCI bursts up to 8 beats, each beat being a 32 bit word. The burst size is programmable. The general approach is to write a PCI command and address to the control register along with the number of bytes to be transmitted (Packet_Size).

When transmitting data, the module will wait for the Transmit FIFO to fill at least to the minimum number of bytes required to perform the programmed burst; then it begins transmitting the data onto the PCI bus. Multi-Channel DMA must handle filling the Transmit FIFO to support the specified number of bytes. Transmission will continue until the specified number of bytes have been sent.

When reading data, the module will check that enough space is available in the Receive FIFO and immediately begin PCI read transactions. Multi-Channel DMA must handle emptying the Receive FIFO to support the specified number of bytes. Transmission will continue until the specified number of bytes have been received. To avoid stale data while receiving the last burst flushing of the RX FIFO can be forced with the set of the flush bit FE. See Section 10.3.3.2.4, “Rx Enables PCIRER(RW).”

At this point, software must restart the procedure by at least re-writing the Packet_Size register. Each transmission of the specified number of bytes is considered a “packet”. A new packet can be instructed to continue at the last valid PCI address or software may choose to write a new starting address. The largest

burst size is 8 PowerPC words and the largest *Packet_Size* is 4 Gbytes, so a packet will typically consist of many PCI data bursts.

The Transmit Controller will wait until sufficient bytes are in the Transmit FIFO to support a full burst and will continue in this mode until the entire packet is transmitted. Similarly, the Receive Controller will stall until sufficient space is available in the Receive FIFO to support a full burst. If the packet is nearly done and the number of bytes remaining to complete the packet is less than Max_beats, the remaining data will be performed as single-beat PCI transactions.

### 10.4.6.1 Access Width

This Multi-Channel DMA module primarily performs 32-bit data accesses to and from PCI, even though some signals are referred to in bytes. The two least significant bits of the PCITPSR and PCIRPSR value are ignored. All PCI byte enables are enabled during these types of accesses. Additionally, the FIFOs should only be accessed using 32-bit accesses.

The Communication Sub-System interface optionally supports 16 bit accesses on the PCI bus. Since reads and writes to and from the FIFO require 32-bit accesses, using this option requires padding the remaining 16 bits of data.

### 10.4.6.2 Addressing

The Communication Sub-System Initiator interface does not use the addressing windows that are set up for the XL bus Initiator Interface. Instead, the Tx Start Address register and Rx Start Address register are used. Software programs these registers with the initial starting address for the packet. The module contains an internal counter which will present the incremented PCI address at the beginning of each successive burst for packet transfers.

### 10.4.6.3 Data Translation

The PCI bus is inherently little endian in its byte ordering. The Comm bus however is big endian. Table 10-61 shows the byte lane mapping between the two buses. Since this interface only allows 32-bit accesses, there is only one entry.

**Table 10-61. Comm bus to PCI Byte Lanes for Memory[1] Transactions**

| Transfer | Comm bus | | | | | | PCI data bus | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cAddress [1:0] | cByte Enable [3:0] | Data Bus | | | | PCI_ AD [1:0] | BE [3:0] | Data Bus | | | |
| | | | 31: 24 | 23: 16 | 15:8 | 7:0 | | | 31:24 | 23:16 | 15:8 | 7:0 |
| long | 00 | 1111 | OP0 | OP1 | OP2 | OP3 | 00 | 0000 | OP3 | OP2 | OP1 | OP0 |

[1] The byte lane translation will be similar for other types of transactions. However, the PCI address may be different as explained in Section 10.4.1.5, “Addressing.”

#### 10.4.6.4 Initialization

The following list is the recommended procedure for setting up either the Transmit or Receive controller.

1. Set the Start Address
2. Set the PCI command, Max_Retries, and Max_Beats
3. Set mode, Continuous or Non-continuous
4. Reset the FIFO
5. Set the FIFO Alarm and Granularity fields
6. Set the Master Enable bit (eventually enable the wanted interrupt in case of errors or even of a normal termination)
7. Set the Reset Controller bit low
8. Setup the BestComm (eventually passing the parameters to the task if needed, enabling, if required, the Task to interrupt the Core when finished, etc.)
9. Start the Task(s). It is not strictly necessary to start a PCI RX or TX task before starting the PCI to transmit/receive as one will ‘wait’ for the other to fill the data in or out of the FIFO.
10. Write the Packet Size value to fire off the transfer

#### 10.4.6.5 Restart and Reset

A Restart sequence (namely writing of the Packet Size register) is required whenever the controller ends a packet transmission, either normally or abnormally. In non-continuous mode, a new Start_Add address is generally required since this value is re-used as the start of the next packet once it is Restarted. In Continuous mode, the Start_Add value is not reused. Instead, the next packet begins where the last one left off, but a Restart sequence is still required to get this next packet started.

Writing a non-zero value to the Packet_Size register generates a Restart pulse to the controller. Depending on the desired mode of operation other register accesses may be required, as described in the following paragraphs.

If Continuous mode is not selected, operation is fairly straight forward. Upon packet termination, Restart will not occur until Packet_Size is written with a non-zero value, even if the packet size is the same it must be re-written. Master Enable bit was previously high and can remain so. Reset Controller bit was previously low and can remain so. Toggling the Master Enable or Reset bit is unnecessary but would not disrupt the transmit controller. If any other Control values, e.g. Start_Add, are to be changed they should be written either prior to writing the Packet_Size value or written while the Master Enable bit is negated and the Reset Controller bit is negated. The recommended approach is to write the control values in order (Packet_Size must be last) and not toggle the Master Enable bit. The Reset bit should remain negated.

If Continuous mode is active, basic operation is still straight forward. A Restart is achieved by writing the Packet_Size register to a non-zero value (just as before). However, the Master Enable and Reset bits must **not** toggle in this case. If the Master Enable bit goes low the Packets_Done counter will be reset. If the Reset bit goes high the Start_Add value will be re-loaded and subsequent transactions will begin at this address. Therefore, the Master Enable bit can be used to reset the Packets_Done counter but without disturbing the current PCI address. The Reset Controller bit will reset the counter and reload the Start_Add

value into the transmit controller, thus achieving a total restart of a continuous mode sequence. In any case, it is still required that the Packet_Size register be written to complete a Restart sequence.

The Master Enable bit, if negated, will prevent a Restart sequence but allows Control values to be updated without order dependency. A side effect is to reset the Packets_Done counter and status, which is a concern in continuous mode only.

The Reset bit (RC bit of the RX/TX Enables register, **NOT** the external PCI RESET line), if asserted, will force a Reset of the controller. All continuous mode effects will be reset and the Start_Add value is re-loaded. However, the Reset bit must be negated while the required write to the Packet_Size register is accomplished. The Reset bit provides the only means to re-load the Start_Add value into the transmit controller while Continuous mode is active. In either mode it provides a means to clear the transmit controller in cases of abnormal termination. Note, a new Start_Add value must be written prior to setting the Reset bit.

### 10.4.6.6 PCI Commands

The expected PCI commands are Memory Write for transmit and Memory Read for receive. These are independent of cache or line size. This permits the number of data beats per transaction to be flexible. If any requirements exist on number of data beats, then the software must carefully consider the possibilities. If the Max_Beats setting does not divide properly into the Packet_Size setting then the packet will end up with one or more single-beat transaction(s). Setting Max_Beats to 1 will force all transactions to be single-beat but will affect throughput.

In normal operation, all PCI byte enables will be asserted for PCI transactions through this interface, except if the 16-bit Word register bit is set in the Tx Transaction Control Register PCITTCR(RW) or Rx Transaction Control Register PCIRTCR(RW), in which case $\overline{BE}[3:0]$ = 1100.

Configuration writes to an external target *should* be handled exclusively by the XL bus Initiator interface.

### 10.4.6.7 FIFO Considerations

Careful consideration must also be given to filling and counting bytes of the Transmit FIFO and emptying and counting bytes of the Receive FIFO. This operation is expected to be accomplished through Multi-Channel DMA which can also perform the register writes to the controller, including necessary Restart sequences.

### 10.4.6.8 Alarms

The FIFO alarm registers allow software to control when the DMA fills or empties the appropriate FIFO.

### 10.4.6.9 Bus Errors

Since Bus Errors are particular to the module register set and that register set includes both Transmit and Receive Controller and FIFO settings, the Bus Error status bits and Bus error Enable bit(s) are duplicated in the Transmit and Receive register groupings. Clearing or setting one will clear or set the other. From a software point of view, then, they can be treated separately or together, as desired.

### 10.4.7 PCI - Supported Clock Ratios

MPC5200B supports the following XL Bus:IP:PCI clock ratios.

**Table 10-62. XL Bus:IP:PCI Clock Ratios**

| XL Bus:IP:PCI | XL Bus CLK | IP CLK | PCI CLK |
|---|---|---|---|
| 4:4:2 | 132 MHz | 132 MHz | 66 MHz |
| 4:4:1 | 132 MHz | 132 MHz | 33 MHz |
| 4:2:2 | 132 MHz | 66 MHz | 66 MHz |
| 4:2:1 | 132 MHz | 66 MHz | 33 MHz |
| 2:2:2 | 66 MHz | 66 MHz | 66 MHz |
| 2:2:1 | 66 MHz | 66 MHz | 33 MHz |
| 2:1:1 | 66 MHz | 33 MHz | 33 MHz |

### 10.4.8 Interrupts

#### 10.4.8.1 PCI Bus Interrupts

MPC5200B does not generate interrupts on the PCI bus interrupt lines INTA - INTD.

#### 10.4.8.2 Internal Interrupt

The PCI module is capable of generating 3 interrupts to MPC5200B interrupt controller in MPC5200B SIU. Each interrupt can be enabled for a variety of conditions, mostly error conditions. For the XL bus Initiator interface, the internal interrupt can be enabled for Retry errors, Target Aborts and Initiator (Master) Aborts. See Section 10.3.2.9, “Initiator Control Register PCIICR(RW)” and Section 10.3.2.10, “Initiator Status Register PCIISR(RWC)” for more information. For the Comm bus Initiator interface, an internal interrupt can be enabled for FIFO errors and Normal Termination of a packet transfer for either the Receive (rx) or Transmit (tx) interface. For more information, see the Enable and Status registers for the Comm bus Transmit and Receive interfaces, Section 10.3.3.1, “Multi-Channel DMA Transmit Interface” and Section 10.3.3.2, “Multi-Channel DMA Receive Interface.”

## 10.5 PCI Arbiter

The PCI Arbiter is a separate module, it is not part of the PCI Controller module. The 32-bit multiplexed PCI A/D bus is shared with the ATA Controller and LocalPlus Controller. The on-chip arbiter (called PCI Arbiter) controls the access to the AD bus for the different clients:

- PCI clients
  - XIPCI (XL Bus-PCI interface)
  - SCPCI (BestComm-PCI interface)
  - external PCI
- non-PCI clients
  - LPC (LocalPlus bus interface)
  - SCLPC (BestComm LocalPlus bus interface)
  - ATA

One pair **only** of external PCI REQ#/GNT# signals is supported by the PCI Arbiter. By an external Priority Encoder multiple external masters could be connected. The PCI bus clock is always sourced from the MPC5200B.

The PCI Arbiter accepts inputs from the external PCI bus, XL bus, LocalPlus bus, and ATA. The arbitration priority is fixed and it operates in a Round-Robin manner. The round-robin fairness algorithm avoids the domination of the bus by high-priority masters and exclusion of low-priority masters.

The last PCI bus master to win arbitration is parked on the internal PCI bus until another master requests the bus. For instance, if ATA was the last PCI bus requestor to be granted the bus, ATA does not have to re-arbitrate for the bus if it is the next requestor.

**NOTE**

The XL bus arbitrator can be programmed to park the PCI module on the XL bus. This should not be confused with the parking of the PCI requestors on the internal PCI bus.

The PCI Arbiter runs independently. The programmability consists of a Soft Reset, which allows to reset the PCI Arbiter, and one status bit to detect the Broken Master condition. and a corresponding enable bit for the generation of a CPU interrupt for the Broken Master condition. All these register bits are located in registers of the PCI Controller.

In case of broken master detection the external PCI REQ# will be disconnected internally and will be re-connected after external deassertion of PCI REQ# or by software (Softreset) or by Hardreset. After broken master detection (bus idle for 16 clocks) the arbiter will ignore any PCI FRAME# assertion.

The PCI Arbiter does not support preemption of the internal masters XIPCI or SCPCI. The internal master is granted until the transaction has been completed. The Latency Timer (LT) cannot terminate any transfer.

## 10.6 Application Information

This section provides example usage of some of the features of the PCI module.

### 10.6.1 XL bus Initiated Transaction Mapping

The use of the PCI Configuration Address Register along with the initiator window registers provide many possibilities for PCI command and address generation. Table 10-63 shows how the PCI Controller accepts read and write requests from a XLB bus master and decodes them to different address ranges resulting in the generation of memory, I/O, configuration, interrupt acknowledge and special cycles on the PCI bus. The Window Registers are defined in Section 10.3.2.6, “Initiator Window 1 Base/Translation Address Register PCIIW1BTAR(RW)” through Section 10.3.2.8, “Initiator Window Configuration Register PCIIWCR(RW).”

**Table 10-63. Transaction Mapping: XL Bus -> PCI**

| XL bus Transaction (XL Bus Slave Interface) | Cache Line Size Register = 8 | Initiator Register Settings | | | | PCI Transaction Controller (XL Bus Initiator Interface) -> PCI Target |
|---|---|---|---|---|---|---|
| | | Initiator Window Configuration bits | | Configuration Address Register | | |
| | | IO/M# | PRC | En | device number == b1_1111 | |
| Single-Beat 1 -> 8 byte Read | x | 0 | b00 | x | x | Memory Read |
| Burst Read (32 bytes) | x | 0 | b00 | x | x | Memory Read |
| Single-Beat 1 -> 8 byte Read | x | 0 | b01 | x | x | Memory Read |
| Burst Read | false | 0 | b01 | x | x | Memory Read |
| Burst Read | true | 0 | b01 | x | x | Memory Read Line |
| Single-Beat 1 -> 8 byte Read | x | 0 | b10 | x | x | Memory Read Multiple |
| Burst Read | x | 0 | b10 | x | x | Memory Read Multiple |
| Single-Beat 1 -> 8 byte, or Burst Write | x | 0 | x | x | x | Memory Write |
| Single-Beat 1 -> 4 byte Read | x | 1 | x | 0 | x | I/O Read |
| Single-Beat 1 -> 4 byte Write | x | 1 | x | 0 | x | I/O Write |
| Single-Beat 1 -> 4 byte Read | x | 1 | x | 1 | false | Configuration Read |
| Single-Beat 1 -> 4 byte Write | x | 1 | x | 1 | false | Configuration Write |
| Single-Beat 1 -> 4 byte Read | x | 1 | x | 1 | true | Interrupt acknowledge |
| Single-Beat 1 -> 4 byte Write | x | 1 | x | 1 | true | Special Cycle |

**Note:**

1. Dual Address Cycles and Memory Write and Invalidate Commands are not supported
2. x means “don’t care”

## 10.6.2 Address Maps

The address mapping in MPC5200B system is setup by software through a number of base address registers. (Section 3.2, “Internal Register Memory Map” for more detail). The internal CPU writes the base address value to module base address register MBAR. MBAR holds the base address for the 256 Kbyte space allocated to internal registers.

### 10.6.2.1 Address Translation

#### 10.6.2.1.1 Inbound Address Translation

The MPC5200B-as-Target occupies 2 memory target address windows on the PCI bus. The location is determined by the values programmed to BAR0 and BAR1 of the PCI Type 00h Configuration space. These inbound memory window sizes are fixed to one 256 Kbyte window (BAR0) and one 1 Gbyte window (BAR1).

PCI inbound address translation allows address translation to any space in the MPC5200B space (4 Gbyte of address space). The target base address translation registers TBATR0 and TBATR1 specify the location of the inbound memory window. These registers are described in Section Section 10.4.3, Configuration Interface. Address translation occurs for all enabled inbound transactions. If the enable bit of the Target Base Address Translation Registers is cleared, MPC5200B aborts all PCI memory transactions to that base address window.

Note, the PCI configuring master can program BAR0 to overlap BAR1. The default address translation value is TBATR0 in that case. It is not recommended to program overlapping BAR0 and BAR1 or overlapping TBATR0 and TBATR1. An overlap of TBATRs can cause data write-over of BAR0 data.

The Initiator Window Base Address Registers are used to decode XL bus addresses for PCI bus transactions. The base address and base address mask values define the upper byte of address to decode. The XL bus address space in MPC5200B dedicated to PCI transactions can be mapped to two 16-Mbyte or larger address spaces in MPC5200B. In normal operation, software should not program either Target Address Window Translation Register to address Initiator Window space. In that event, MPC5200B-as-Target transaction would propagate through MPC5200B's internal bus and request PCI bus access as the PCI Initiator. The PCI arbiter could see the PCI bus as busy (target read transaction in progress) and only a time-out would free the PCI bus.

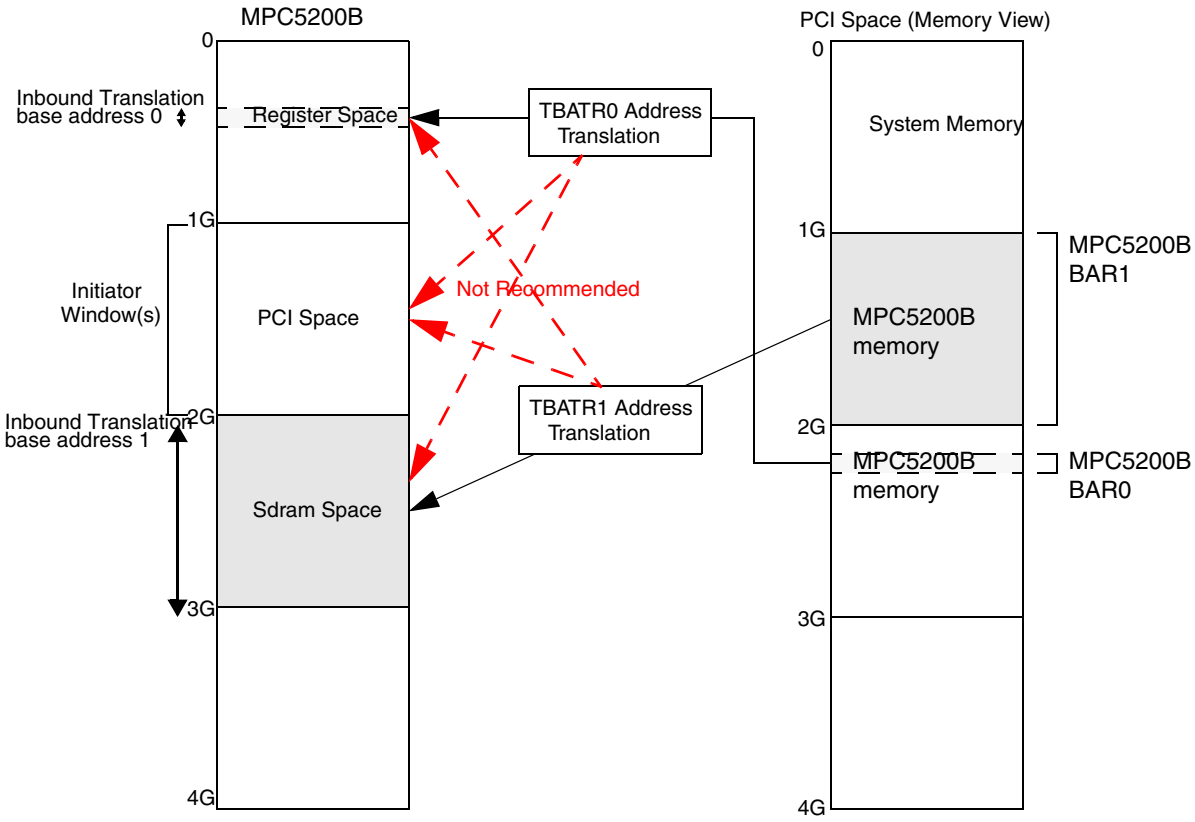



**Figure 10-56. Inbound Address Map**

### 10.6.2.1.2 Outbound Address Translation

Figure 10-57 shows example XL Bus Initiator Window configurations. Overlapping the inbound memory window (MPC5200B Memory) and the outbound translation window is not supported and can cause unpredictable behavior.

This figure doesn't show configuration mechanism.

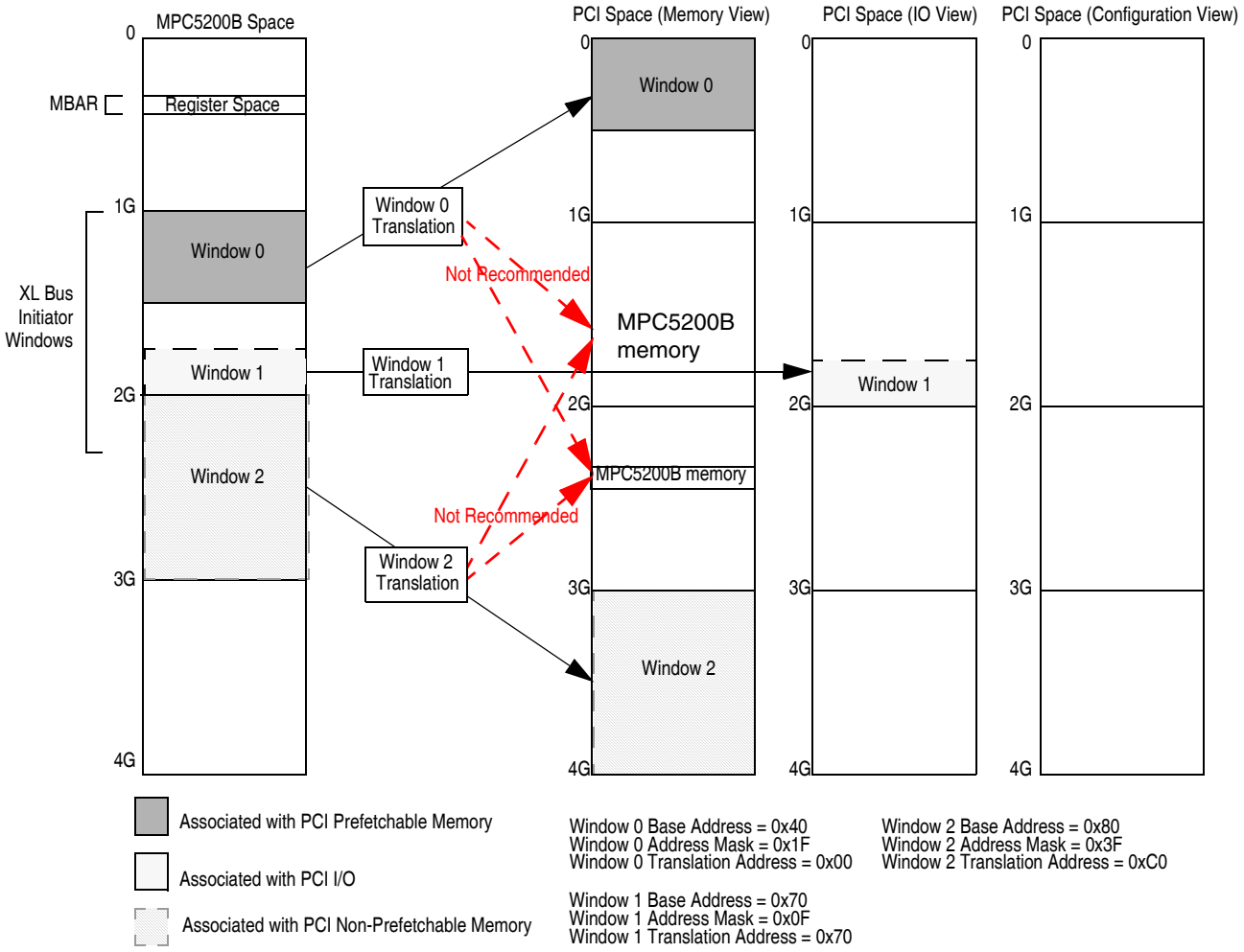



**Figure 10-57. Outbound Address Map**

#### 10.6.2.1.3 Base Address Register Overview

Table 10-63 shows the available accessibility for all PCI associated base address and translation address registers in MPC5200B.

| Base Address Register | Register Function | PCI Bus Configuration Access | Processor Access | Any XL bus Master Access |
|---|---|---|---|---|
| BAR0 | PCI Base Address Register 0 (256 Kbyte) | X | X | X |
| BAR1 | PCI Base Address Register 1 (1 Gbyte) | X | X | X |
| TBATR0 | Target Base Address Translation Register 0 (256Kbyte) | | X | X |
| TBATR1 | Target Base Address Translation Register 0 (1 Gbyte) | | X | X |
| IMWBAR | Initiator Window Base/Translation Address Registers | | X | X |

## 10.6.3 XL bus Arbitration Priority

When the XL Bus Arbiter Master Priority Register (Section 16.2.1.1, “Arbiter Configuration Register (R/W)”) is set to any configuration except all-master fair-share (all masters have the same priority), live lock can occur on the shared PCI bus and the XL Bus, which results in system-wide live lock.

The only resolution that guarantees that this live lock scenario will not occur is to set all the XL Bus Arbiter master priorities to be equal. Additionally, it is usually preferable that all master priorities are not set to zero, as this can generate an interrupt by the XL Bus Arbiter, if enabled.

# Chapter 11
# ATA Controller

## 11.1 Overview

The following sections are contained in this document:

- BestComm Key Features
  - — ATA Register Interface, includes:
  - — ATA Host Registers
  - — ATA FIFO Registers
  - — ATA Drive Registers
- ATA Host Controller Operation
- Signals and Connections
- ATA Interface Description
- ATA Bus Background
- ATA RESET/Power-Up
- ATA I/O Cable Specifications

The Advanced Technology Attachment (ATA) Controller provides full functional compatibility with ATA-4 documentation, supporting Ultra-33. For more ATA Standards information, refer to American *National Standard for Information Technology—AT Attachment with Packet Interface Extension (ATA/ATAPI-4)*.

A dedicated MPC5200B pin for ATA reset is *not* provided. An appropriate signal on the board should be routed to the reset input on the ATA connector. If ATA reset is tied to $\overline{\text{HRESET}}$ or $\overline{\text{SRESET}}$ on MPC5200B pins, they are asserted and internally held low for an appropriate period of time to satisfy ATA reset. An MPC5200B GPIO may be used to drive ATA reset independently if special software control is needed.

Figure 11-1 shows the ATA Controller Interface.

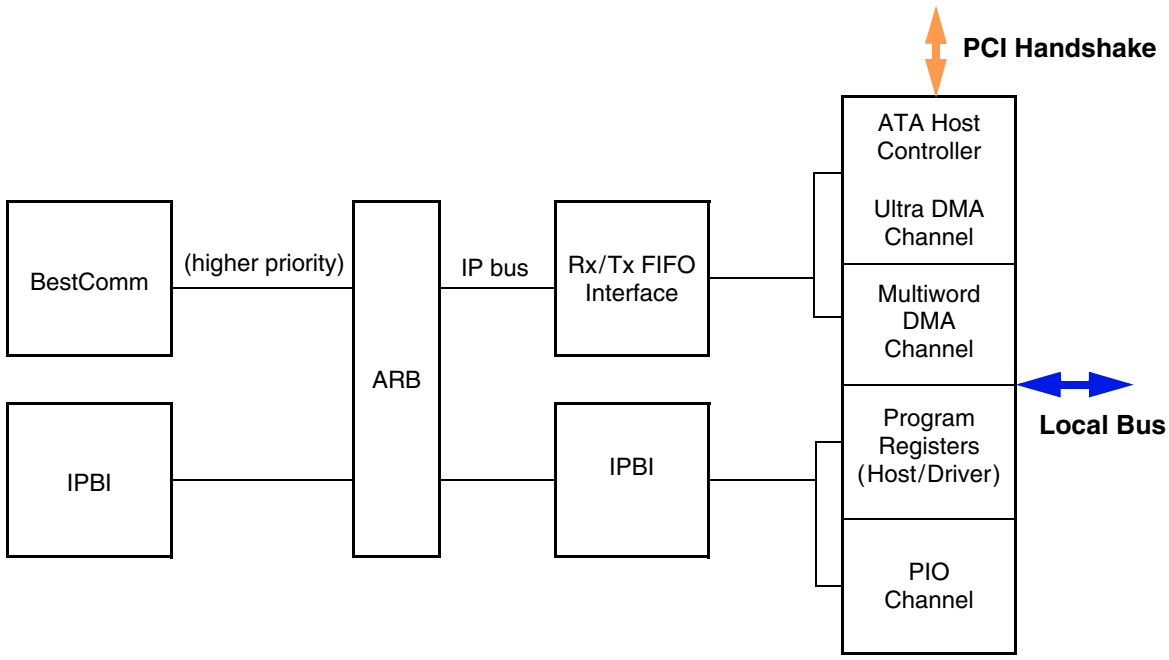



**Figure 11-1. ATA Controller Interface**

## 11.2 BestComm Key Features

### 11.2.1 BestComm Read

1. microprocessor sets up descriptors in BestComm RAM and initiates a transfer.
2. BestComm hits on an ATA command FIFO space and writes a command (ATA drive register address, transfer size) into FIFO.
3. ATA Controller reads data from the drive and puts data in FIFO.
4. As FIFO fills, BestComm is interrupted and moves data from FIFO to an internal destination.

### 11.2.2 BestComm Write

1. microprocessor sets up descriptors in BestComm RAM and initiates a transfer.
2. BestComm hits on an ATA command FIFO space and writes a command (ATA drive register address, transfer size) into FIFO.
3. BestComm reads data from internal source and puts data in FIFO
4. ATA Controller transfers data from FIFO and writes to drive.

**NOTE**

Any DMA transfer, where source and destination are both on the local bus, requires internal BestComm SRAM buffering.

## 11.3 ATA Register Interface

The IPBI module contains all software-programmable ATA Controller registers and the IPB glue logic needed to read and write these registers. The IPBI registers are listed below. Unless otherwise noted, each register is written and read from the same address.

### 11.3.1 ATA Host Registers

ATA is controlled by 10 32-bit registers. These registers are located at an offset from MBAR of 0x3A00. Register addresses are relative to this offset. Therefore, the actual register address is: **MBAR + 0x3A00 + register address**

Hyperlinks to the ATA Host registers are provided below:

- ATA Host Configuration Register (0x3A00)
- ATA Host Status Register (0x3A04)
- ATA PIO Timing 1 Register (0x3A08)
- ATA PIO Timing 2 Register (0x3A0C)
- ATA Multiword DMA Timing 1 Register (0x3A10)
- ATA Multiword DMA Timing 2 Register (0x3A14)
- ATA Ultra DMA Timing 1 Register (0x3A18)
- ATA Ultra DMA Timing 2 Register (0x3A1C)
- ATA Ultra DMA Timing 3 Register (0x3A20)
- ATA Ultra DMA Timing 4 Register (0x3A24)
- ATA Ultra DMA Timing 5 Register (0x3A28)

### 11.3.1.1 ATA Host Configuration Register

Address MBAR + 0x3A00

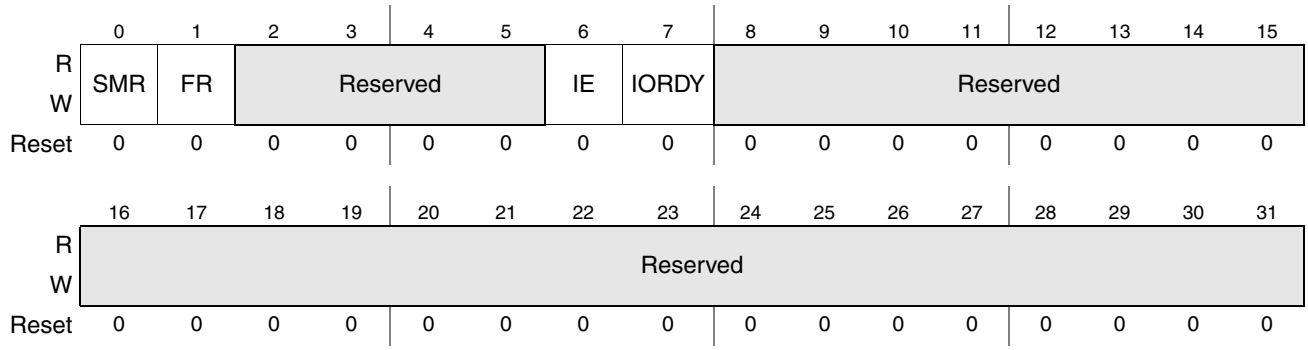



**Figure 11-2. ATA Host Configuration Register**

**Table 11-1. ATA Host Configuration Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | SMR | State Machine Reset—bit resets ATA state machine to IDLE state for PIO, DMA and UDMA read/write. |
| 1 | FR | FIFO Reset—bit can be used to reset FIFO when bit 0 of this register is set to reset the ATA state machine. During normal ATA transaction, FIFO can be reset by setting ATA Drive Command Register FR bit (see Table 11-30.) |
| 2:5 | — | Reserved |
| 6 | IE | Enables drive interrupt to pass to CPU in PIO modes. |
| 7 | IORDY | Set by software when the drive supports IORDY. Required for PIO mode 3 and above. |
| 16:31 | — | Reserved |

### 11.3.1.2 ATA Host Status Register

Address MBAR + 0x3A04

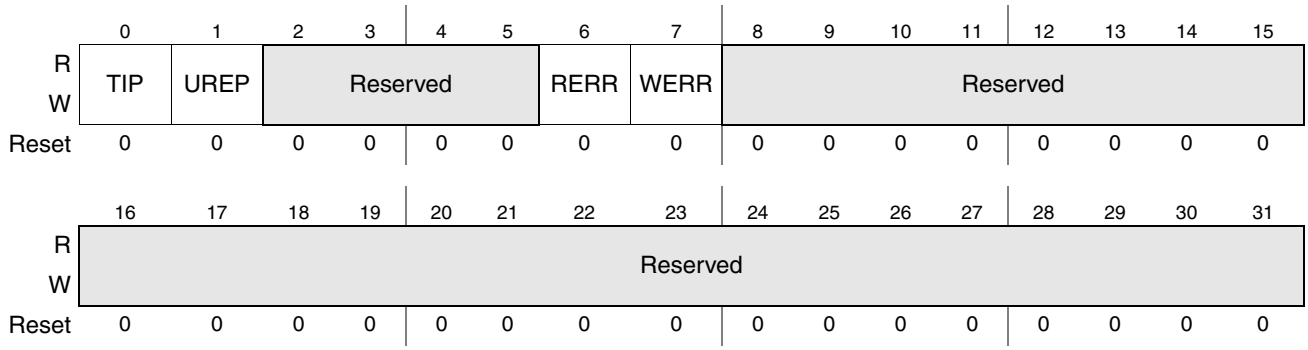



**Figure 11-3. ATA Host Status Register**

**Table 11-2. ATA Host Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | TIP | Transaction in Progress—indicator bit MUST be polled by software before PIO access. System bus (XL bus) locks up if PIO access is attempted while this bit is set. This bit is read-only. |
| 1 | UREP | UDMA Read Extended Pause—bit sets when drive stops strobing for an extended period without initiating burst termination by negating DMARQ, during an UDMA read burst. Software may initiate an Ultra DMA read burst termination, in this case by setting ATA Drive Device Command Register HUT bit (see Table 11-30.). |
| 2:5 | — | Reserved |
| 6 | RERR | Read Error—An un-implemented register read. |
| 7 | WERR | Write Error—An un-implemented register write. |
| 8:31 | — | Reserved |

### 11.3.1.3 ATA PIO Timing 1 Register

Address MBAR + 0x3A08

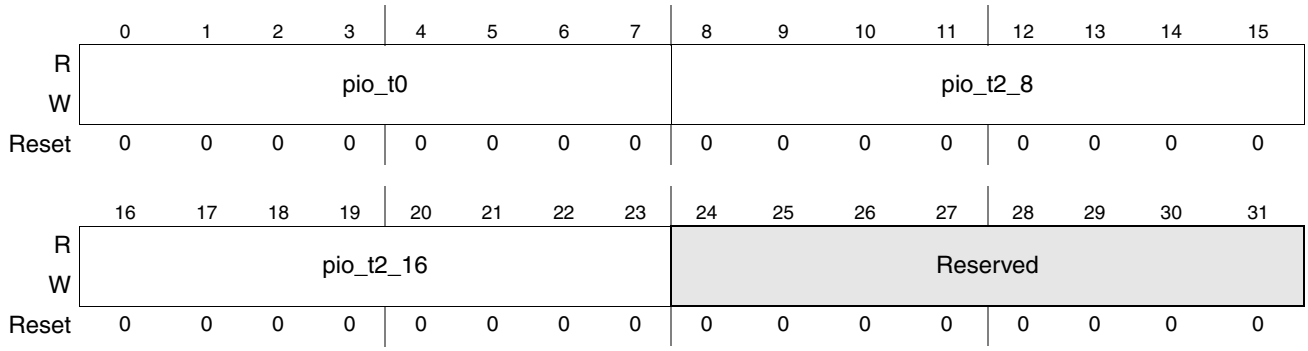



**Figure 11-4. ATA PIO Timing 1 Register**

**Table 11-3. ATA PIO Timing 1 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | pio_t0 | PIO cycle time count value is based on system clock operating frequency. |
| 8:15 | pio_t2_8 | PIO read/write pulse width for 8-bit transfers. Count value is based on system clock operating frequency. |
| 16:23 | pio_t2_16 | PIO read/write pulse width for 16-bit transfers. Count value is based on system clock operating frequency. |
| 24:31 | — | Reserved |

### 11.3.1.4 ATA PIO Timing 2 Register

Address MBAR + 0x3A0C

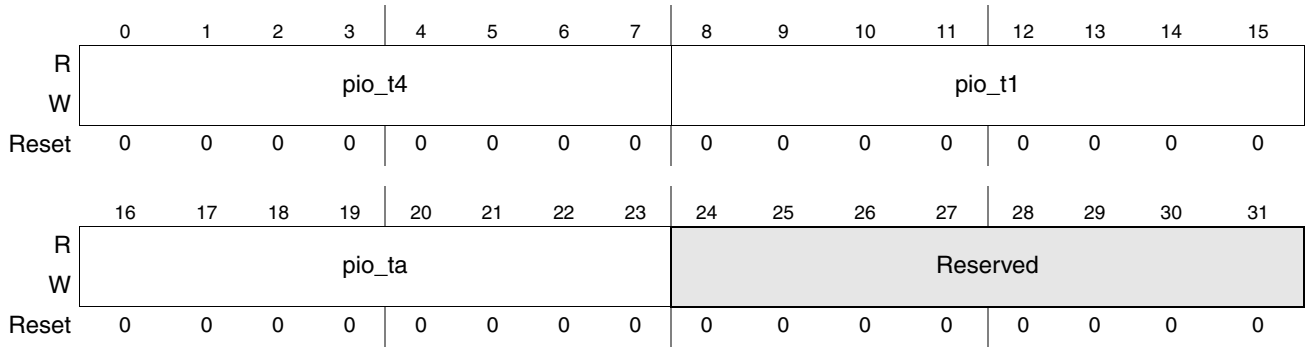



**Figure 11-5. ATA PIO Timing 2 Register**

**Table 11-4. ATA PIO Timing 2 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | pio_t4 | PIO write (DIOW) data hold time. Count value is based on system clock operating frequency. |
| 8:15 | pio_t1 | Address valid to DIOR/DIOW setup. Count value is based on system clock operating frequency. |
| 16:23 | pio_ta | IORDY setup time. Count value is based on system clock operating frequency. |
| 24:31 | — | Reserved |

### 11.3.1.5 ATA Multiword DMA Timing 1 Register

Address MBAR + 0x3A10

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | dma_t0 | | | | | | | | dma_td | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | dma_tk | | | | | | | | dma_tm | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 11-6. ATA Multiword DMA Timing 1 Register**

**Table 11-5. ATA Multiword DMA Timing 1 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | dma_t0 | Multiword DMA cycle time. Count value is based on system clock operating frequency. |
| 8:15 | dma_td | Multiword DMA read/write (DIOR/DIOW) asserted pulse width. Count value is based on system clock operating frequency. |
| 16:23 | dma_tk | Multiword DMA read/write (DIOR/DIOW) negated pulse width. Count value is based on system clock operating frequency. |
| 24:31 | dma_tm | $\overline{CS}$[0], $\overline{CS}$[1] valid to DIOR/DIOW. Count value is based on system clock operating frequency. |

### 11.3.1.6 ATA Multiword DMA Timing 2 Register

Address MBAR + 0x3A14

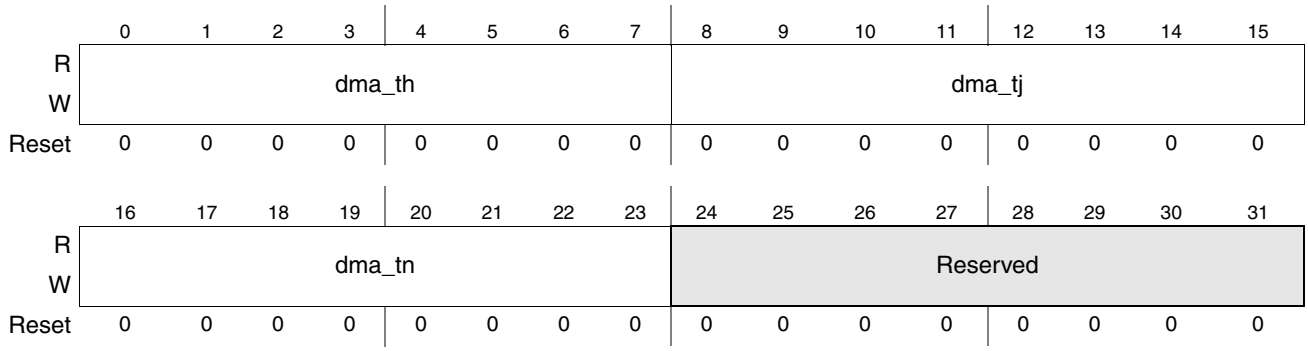



**Figure 11-7. ATA Multiword DMA Timing 2 Register**

**Table 11-6. ATA Multiword DMA Timing 2 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | dma_th | Multiword DMA write (DIOW) data hold time. Count value is based on system clock operating frequency. |
| 8:15 | dma_tj | Multiword DMA read/write (DIOR/DIOW) asserted pulse width. Count value is based on system clock operating frequency. |
| 16:23 | dma_tn | $\overline{CS}$[0], $\overline{CS}$[1] hold. Count value is based on system clock operating frequency. |
| 24:31 | — | Reserved |

### 11.3.1.7 ATA Ultra DMA Timing 1 Register

Address MBAR + 0x3A18

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | udma_t2cyc | | | | | | | | udma_tcyc | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | udma_tds | | | | | | | | udma_tdh | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 11-8. ATA Ultra DMA Timing 1 Register**

**Table 11-7. ATA Ultra DMA Timing 1 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | udma_t2cyc | Ultra DMA sustained average two cycle time. Count value is based on system clock operating frequency. |
| 8:15 | udma_tcyc | Ultra DMA strobe edge to strobe edge cycle time. Count value is based on system clock operating frequency. |
| 16:23 | udma_tds | Ultra DMA read data setup time. Count value is based on system clock operating frequency. |
| 24:31 | udma_tdh | Ultra DMA read data hold time. Count value is based on system clock operating frequency. |

### 11.3.1.8 ATA Ultra DMA Timing 2 Register

Address MBAR + 0x3A1C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | udma_tdvs | | | | | | | | udma_tdvh | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | udma_tfs | | | | | | | | udma_tli | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 11-9. ATA Ultra DMA Timing 2 Register**

**Table 11-8. ATA Ultra DMA Timing 2 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | udma_tdvs | Ultra DMA write data setup time. Count value is based on system clock operating frequency. |
| 8:15 | udma_tdvh | Ultra DMA write data hold time. Count value is based on system clock operating frequency. |
| 16:23 | udma_tfs | First strobe time during the initiation of ultra DMA data transfer. Count value is based on system clock operating frequency. |
| 24:31 | udma_tli | Limited interlock time with a defined maximum, when drive or host are waiting for response from each other. Count value is based on system clock operating frequency. |

### 11.3.1.9 ATA Ultra DMA Timing 3 Register

Address MBAR + 0x3A20

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | udma_tmli | | | | | | | | udma_taz | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | udma_tenv | | | | | | | | udma_tsri | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 11-10. ATA Ultra DMA Timing 3 Register**

**Table 11-9. ATA Ultra DMA Timing 3 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | udma_tmli | Limited interlock time with a defined minimum, when drive or host are waiting for response from each other. Count value is based on system clock operating frequency. |
| 8:15 | udma_taz | Maximum time allowed for output drivers to release from being driven. Count value is based on system clock operating frequency. |
| 16:23 | udma_tenv | Envelope time from DMACK to STOP and HDMARDY during data-out burst initiation. Count value is based on system clock operating frequency. |
| 24:31 | udma_tsr | Strobe to DMARDY time. If DMARDY is negated before this long after strobe edge the recipient receives no more than one additional data word. Count value is based on system clock operating frequency. |

### 11.3.1.10 ATA Ultra DMA Timing 4 Register

Address MBAR + 0x3A24

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | udma_tss | | | | | | | | udma_trfs | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | udma_trp | | | | | | | | udma_tac | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 11-11. ATA Ultra DMA Timing 4 Register**

**Table 11-10. ATA Ultra DMA Timing 4 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | udma_tss | Time from strobe edge to negation of DMARQ (when drive terminates burst) or assertion of STOP (when host terminates burst). Count value is based on system clock operating frequency. |
| 8:15 | udma_trfs | Ready-to-final-strobe time. No strobe edges are sent this long after negation of DMARDY. Count value is based on system clock operating frequency. |
| 16:23 | udma_trp | Ready-to-pause time. The time that recipient waits to initiate pause after negating DMARDY. Count value is based on system clock operating frequency. |
| 24:31 | udma_tack | Setup and hold times for DMACK before negation or assertion. Count value is based on system clock operating frequency. |

### 11.3.1.11 ATA Ultra DMA Timing 5 Register

Address MBAR + 0x3A28

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | udma_tzah | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 11-12. ATA Ultra DMA Timing 5 Register**

**Table 11-11. ATA Ultra DMA Timing 5 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | udma_tzah | Minimum delay time required for output drivers to assert or negate from release state. Count value is based on system clock operating frequency. |
| 8:31 | — | Reserved |

### 11.3.1.12 ATA Share Count Register

Address MBAR + 0x3A2C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | ata_share_cnt | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 11-13. ATA Share Count Register**

**Table 11-12. ATA Share Count Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:15 | ata_share_cnt | This 16-bit value controls the length of the “time slot” assigned to ATA transactions when PCI arbiter provides a grant to the ATA device. This is in IPB clocks. The arbiter will maintain the grant to ATA for (at least) the ata_share_cnt value. When this value has expired, ATA may be interrupted (paused) by the arbiter, to service other pending requests for the AD bus. Default value at reset is 128<br>**Note:** The maximal allowed setting is 0xFFFE. |
| 16:31 | — | Reserved |

## 11.3.2 ATA FIFO Registers

ATA uses a single FIFO that changes direction based on the Rx/Tx mode. Software controls direction change and flushes FIFO before changing directions. FIFO memory is 512 Bytes (Four 8 x 128 memories).

ATA FIFO is controlled by 32-bit registers. These registers are located at an offset from MBAR of 0x3a00. Register addresses are relative to this offset. Therefore, the actual register address is: **MBAR + 0x3A00 + register address**

Hyperlinks to the ATA FIFO registers are provided below:

- ATA Rx/Tx FIFO Data Word Register (0x3A3C)
- ATA Rx/Tx FIFO Status Register (0x3A40)
- ATA Rx/Tx FIFO Control Register (0x3A44)
- ATA Rx/Tx FIFO Alarm Register (0x3A48)
- ATA Rx/Tx FIFO Read Pointer Register (0x3A4C)
- ATA Rx/Tx FIFO Write Pointer Register (0x3A50)

### 11.3.2.1 ATA Rx/Tx FIFO Data Word Register

Address MBAR + 0x3A3C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | FIFO_Data_Word | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | FIFO_Data_Word | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 11-14. ATA Rx/Tx FIFO Data Word Register**

**Table 11-13. ATA Rx/Tx FIFO Data Word Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | FIFO_Data_Word | The FIFO data port. Reading from this location “pops” data from the FIFO, writing “pushes” data into the FIFO. During normal operation the BestComm Controller pushes data here.<br>**Note:** ONLY full long-word access is allowed. If all byte enables are not asserted when accessing this location, a FIFO error flag is generated. |

### 11.3.2.2 ATA Rx/Tx FIFO Status Register

Address MBAR + 0x3A40

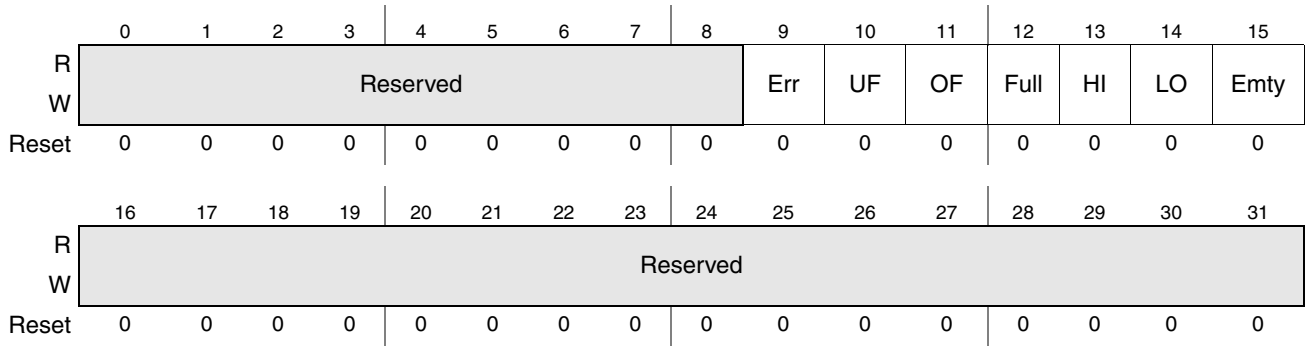



**Figure 11-15. ATA Rx/Tx FIFO Status Register**

**Table 11-14. ATA Rx/Tx FIFO Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:8 | — | Reserved |
| 9 | Err | Error—flag bit is essentially the logical OR of other flag bits and can be polled for detection of any FIFO error. After clearing the offending condition, writing 1 to this bit clears flag. |
| 10 | UF | UnderFlow—flag indicates read pointer has surpassed the write pointer. FIFO was read beyond empty. Resetting FIFO clears this condition; writing 1 to this bit clears flag. |
| 11 | OF | OverFlow—flag indicates write pointer surpassed read pointer. FIFO was written beyond full. Resetting FIFO clears this condition; writing 1 to this bit clears flag. |
| 12 | Full | FIFO full—this is NOT a sticky bit or error condition. Full indication tracks with FIFO state. |
| 13 | HI | High—FIFO requests attention, because high level alarm is asserted. To clear this condition, FIFO must be read to a level below the setting in granularity bits. |
| 14 | LO | Low—FIFO requests attention, because Low level alarm is asserted. To clear this condition, FIFO must be written to a level in which the space remaining is less than the granularity bit setting. |
| 15 | Emty | FIFO empty—this is NOT a sticky bit or error condition. Full indication tracks with FIFO state. |
| 16:31 | — | Reserved |

### 11.3.2.3 ATA Rx/Tx FIFO Control Register

Address MBAR + 0x3A44

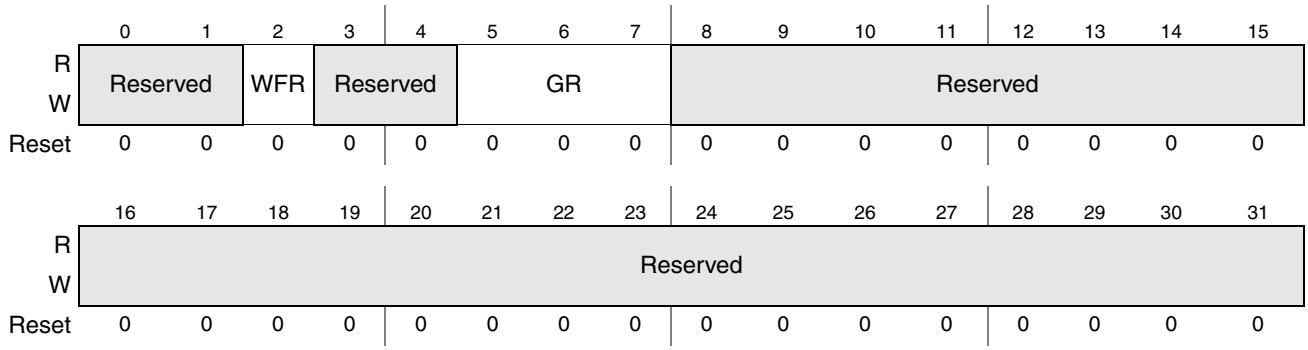



**Figure 11-16. ATA Rx/Tx FIFO Control Register**

**Table 11-15. ATA Rx/Tx FIFO Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2 | WFR | Write End of Frame (EOF) This bit should remain low. |
| 3:4 | — | Reserved |
| 5:7 | GR | Granularity—bits control high “watermark” point at which FIFO negates Alarm condition (i.e., request for data). It represents the number of free bytes times 4.<br>000 = FIFO waits to become completely full before stopping data request.<br>001 = FIFO stops data request when only one long word of space remains. |
| 8:31 | — | Reserved |

### 11.3.2.4 ATA Rx/Tx FIFO Alarm Register

Address MBAR + 0x3A48

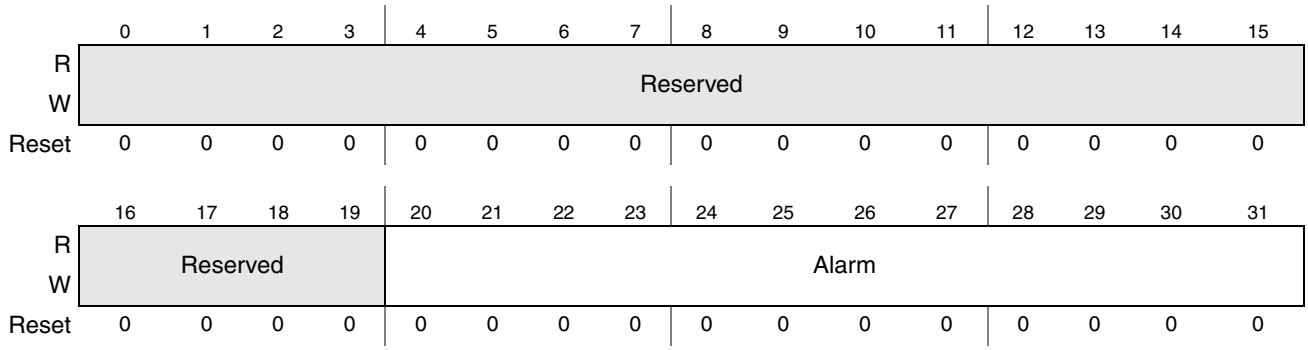



**Figure 11-17. ATA Rx/Tx FIFO Alarm Register**

**Table 11-16. ATA Rx/Tx FIFO Alarm Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:19 | — | Reserved |
| 20:31 | Alarm | User writes these bits to set low level “watermark”, which is the point where FIFO asserts request for BestComm Controller data filling. Value is in bytes. For example, with Alarm = 32, alarm condition occurs when FIFO contains 32 Bytes or less. Once asserted, alarm does not negate until high level mark is reached, as specified by FIFO control register granularity bits. |

### 11.3.2.5 ATA Rx/Tx FIFO Read Pointer Register

Address MBAR + 0x3A4C

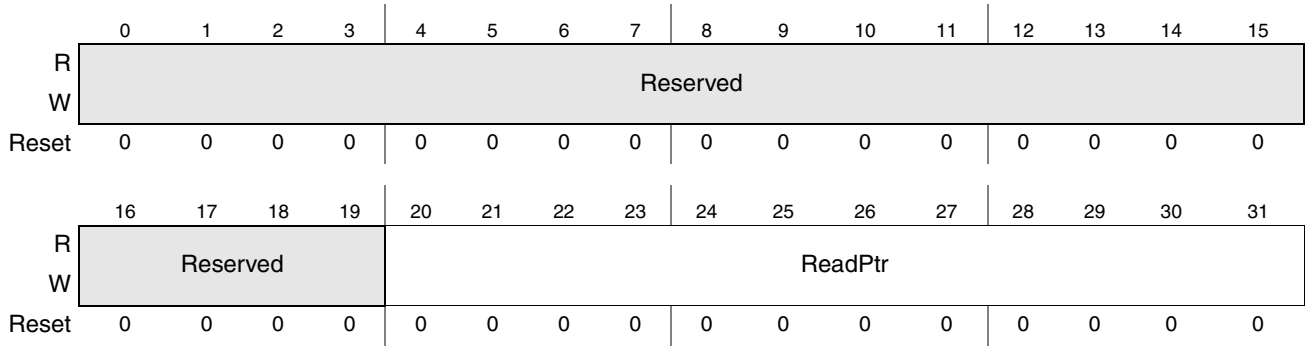



**Figure 11-18. ATA Rx/Tx FIFO Read Pointer Register**

**Table 11-17. ATA Rx/Tx FIFO Read Pointer Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:19 | — | Reserved |
| 20:31 | ReadPtr | Value is maintained by FIFO hardware and is NOT normally written. It can be adjusted in special cases, but this disrupts data flow integrity. Value represents the Read address presented to the FIFO RAM. |

### 11.3.2.6 ATA Rx/Tx FIFO Write Pointer Register

Address MBAR + 0x3A50

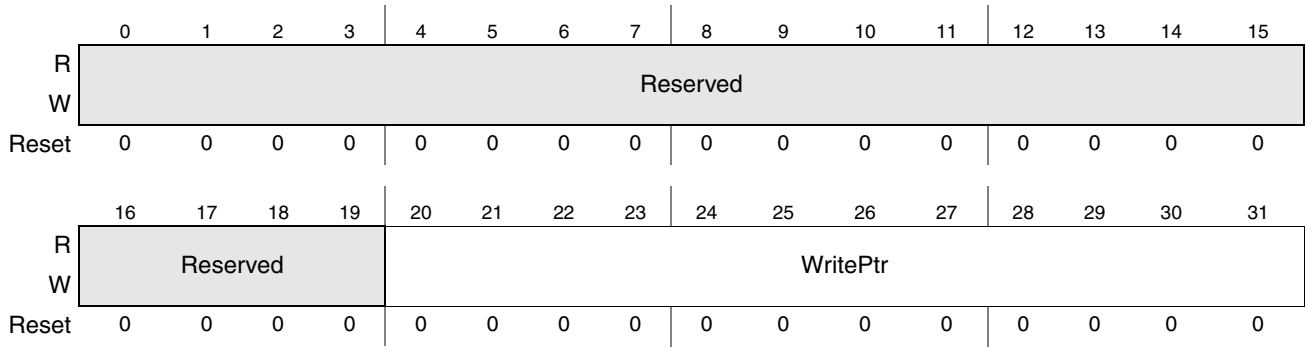



**Figure 11-19. ATA Rx/Tx FIFO Write Pointer Register**

**Table 11-18. ATA Rx/Tx FIFO Write Pointer Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:19 | — | Reserved |
| 20:31 | WritePtr | Value is maintained by FIFO hardware and is NOT normally written. It can be adjusted in special cases, but this disrupts data flow integrity. Value represents the Read address presented to the FIFO RAM. |

### 11.3.3 ATA Drive Registers

The ATA drive registers are physically located inside the drive controller on the ATA disk drive. The MPC5200B ATA Host Controller provides access to these registers using the chip selects and address bits.

ATA Drive is controlled by 32-bit registers. These registers are located at an offset from MBAR of 0x3A00. Register addresses are relative to this offset. Therefore, the actual register address is: **MBAR + 0x3A00 + register address**

Hyperlinks to the ATA Drive registers are provided below:

- ATA Drive Device Control Register (0x3A5C), write-only
- ATA Drive Alternate Status Register (0x3A5C), read-only
- ATA Drive Data Register (0x3A60), R/W
- ATA Drive Features Register (0x3A64), write-only
- ATA Drive Error Register (0x3A64), read-only
- ATA Drive Sector Count Register (0x3A68), R/W
- ATA Drive Sector Number Register (0x3A6C), R/W
- ATA Drive Cylinder Low Register (0x3A70), R/W
- ATA Drive Cylinder High Register (0x3A74), R/W
- ATA Drive Device/Head Register (0x3A78), R/W
- ATA Drive Device Command Register (0x3A7C), write-only
- ATA Drive Device Status Register (0x3A7C), read-only

### 11.3.3.1 ATA Drive Device Control Register

Address MBAR + 0x3A5C

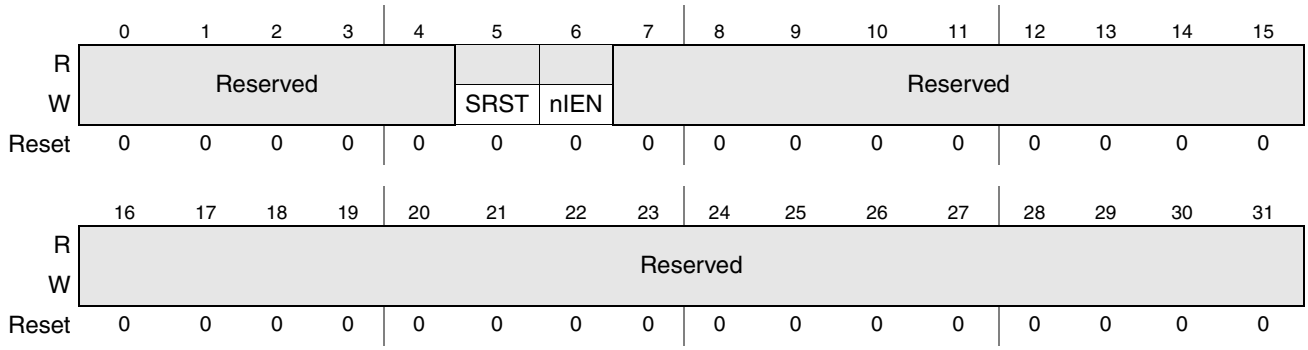



**Figure 11-20. ATA Drive Device Control Register**

**Table 11-19. ATA Drive Device Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:4 | — | Reserved |
| 5 | SRST | Software Reset—Host controlled software reset bit. Drive executes software reset protocol when bit is set to 1 by host. |
| 6 | nIEN | Interrupt Enable—Host controlled interrupt enable. INTRQ is enabled when this bit is cleared to 0.<br>**Note:** For MPC5200B ATA Host Controller, enabling INTRQ is mandatory for DMA/UDMA data transfer modes. |
| 7:31 | — | Reserved |

### 11.3.3.2 ATA Drive Alternate Status Register

Address MBAR + 0x3A5C

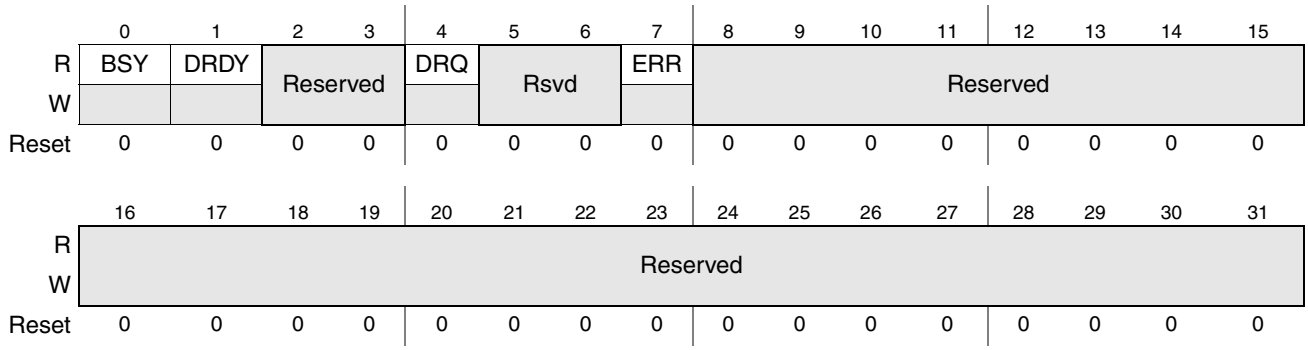



**Figure 11-21. ATA Drive Alternate Status Register**

**Table 11-20. ATA Drive Alternate Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | BSY | Drive Busy—Transactions internal to drive are in progress. Host must wait. |
| 1 | DRDY | Drive Ready |
| 2:3 | — | Reserved |
| 4 | DRQ | Set to 1 indicates drive is ready to transfer a word of data. |
| 5:6 | — | Reserved |
| 7 | ERR | Indicates an error during the execution of the previous command. |
| 8:31 | — | Reserved |

### 11.3.3.3 ATA Drive Data Register

Address MBAR + 0x3A60

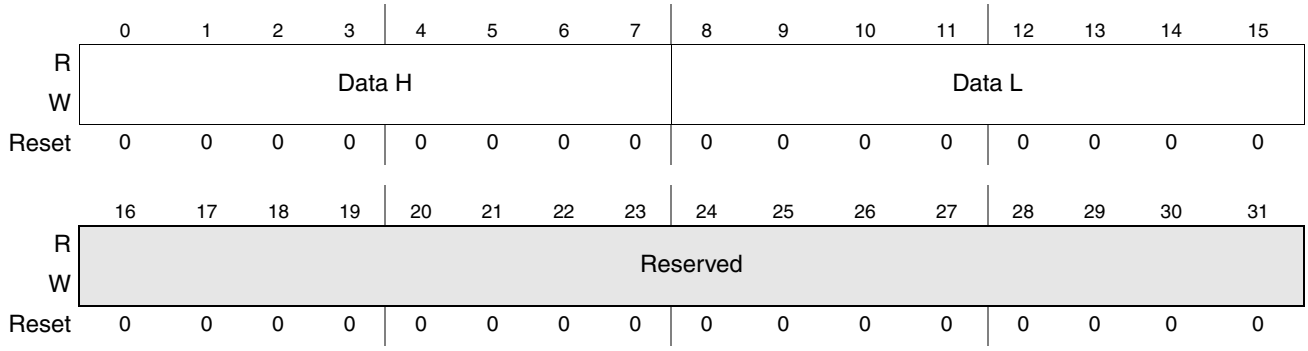



**Figure 11-22. ATA Drive Data Register**

**Table 11-21. ATA Drive Data Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | Data H | Upper byte of drive data (read/write) |
| 8:15 | Data L | Lower byte of drive data (read/write) |
| 16:31 | — | Reserved |

### 11.3.3.4 ATA Drive Features Register

Address MBAR + 0x3A64

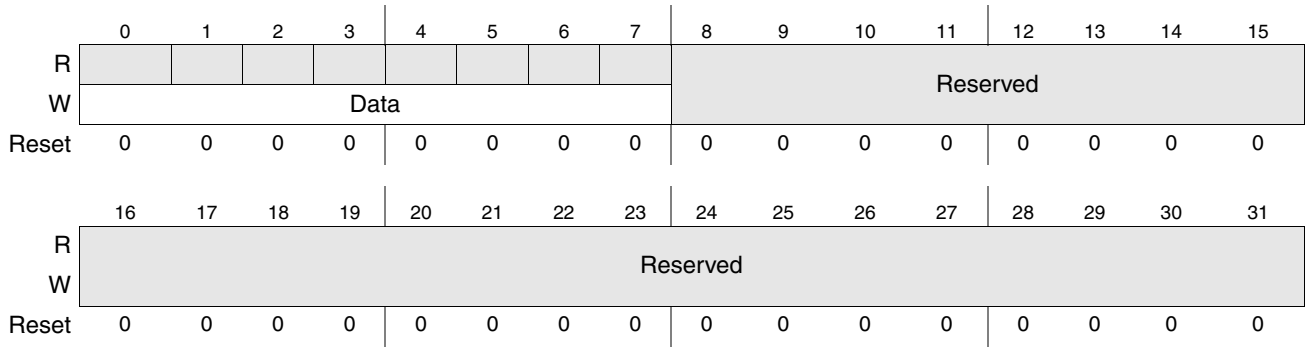



**Figure 11-23. ATA Drive Features Register**

**Table 11-22. ATA Drive Features Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | Data | Register content is command dependent. Contents become command parameters when the ATA drive command register is written. |
| 8:31 | — | Reserved |

### 11.3.3.5 ATA Drive Error Register

Address MBAR + 0x3A64

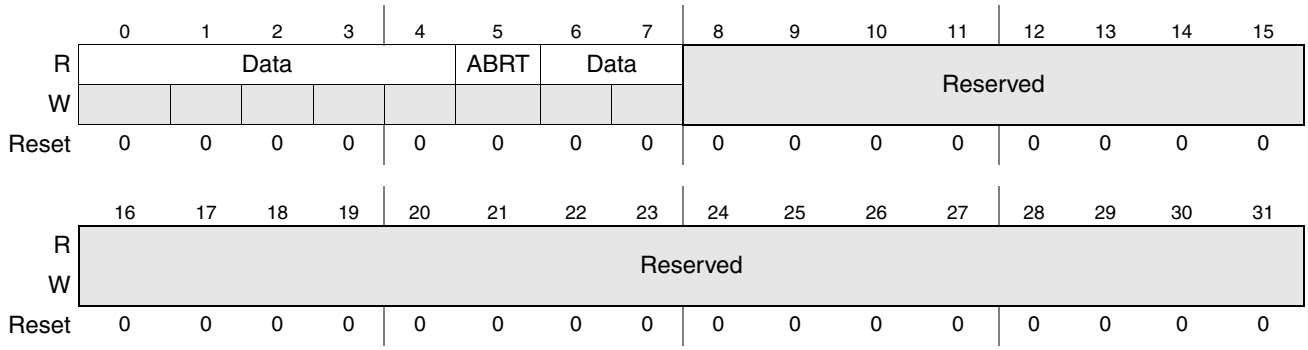



**Figure 11-24. ATA Drive Error Register**

**Table 11-23. ATA Drive Error Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:4 | Data | Register content is command dependent. Contents become command parameters when the ATA drive command register is written.<br>Register content is valid when BSY and DRQ bits are set to 0 and ERR bit is set to 1 in the ATA drive status register. Register content is not valid when drive is in sleep mode. |
| 5 | ABRT | Bit is set to 1 to indicate requested command has been aborted, because command code or a command parameter is invalid or some other error occurred. |
| 0:7 | Data | Register content is command dependent. Contents become command parameters when the ATA drive command register is written.<br>Register content is valid when BSY and DRQ bits are set to 0 and ERR bit is set to 1 in the ATA drive status register. Register content is not valid when drive is in sleep mode. |
| 8:31 | — | Reserved |

### 11.3.3.6 ATA Drive Sector Count Register

Address MBAR + 0x3A68

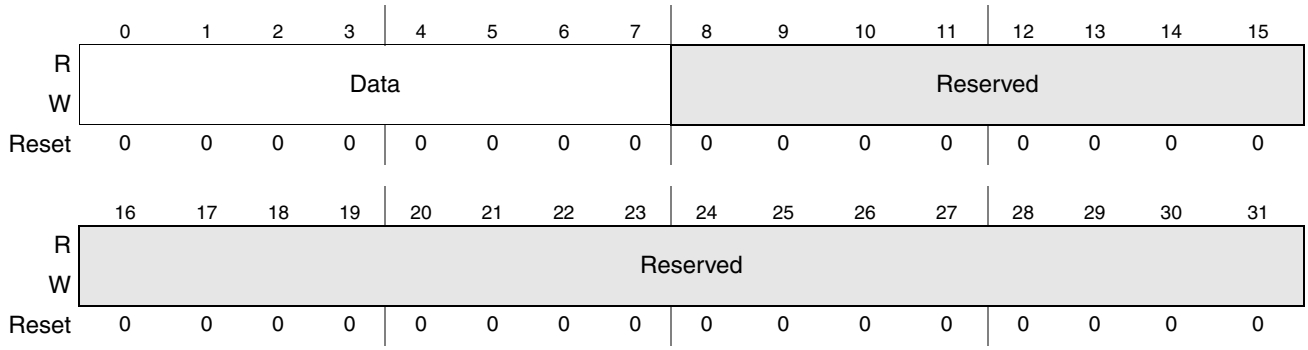



**Figure 11-25. ATA Drive Sector Count Register**

**Table 11-24. ATA Drive Sector Count Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | Data | Bit content is command dependent. For most read/write commands, this register indicates the total number of sectors requested for transfer.<br>Register is written only when ATA drive status register bits BSY and DRQ equal 0 and $\overline{\text{DMACK}}$ is not asserted. If register is written when BSY and DRQ bits are set to 1, the result is indeterminate. Register content is not valid when drive is in sleep mode. |
| 8:31 | — | Reserved |

### 11.3.3.7 ATA Drive Sector Number Register

Address MBAR + 0x3A6C

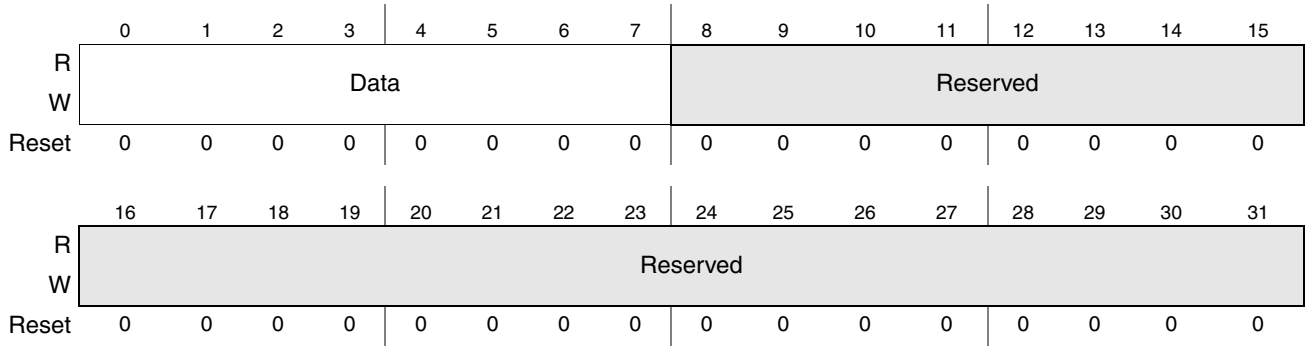



**Figure 11-26. ATA Drive Sector Number Register**

**Table 11-25. ATA Drive Sector Number Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | Data | Bit content is command dependent. For most commands, this register indicates the data transfer starting sector number for when CHS addressing is enabled. This register indicates part of the LBA address when the LBA addressing is enabled.<br>Register is written only when ATA drive status register bits BSY and DRQ equal 0 and $\overline{\text{DMACK}}$ is not asserted. If register is written when BSY and DRQ bits are set to 1, the result is indeterminate. Register content is not valid when drive is in sleep mode. |
| 8:31 | — | Reserved |

### 11.3.3.8 ATA Drive Cylinder Low Register

Address MBAR + 0x3A70

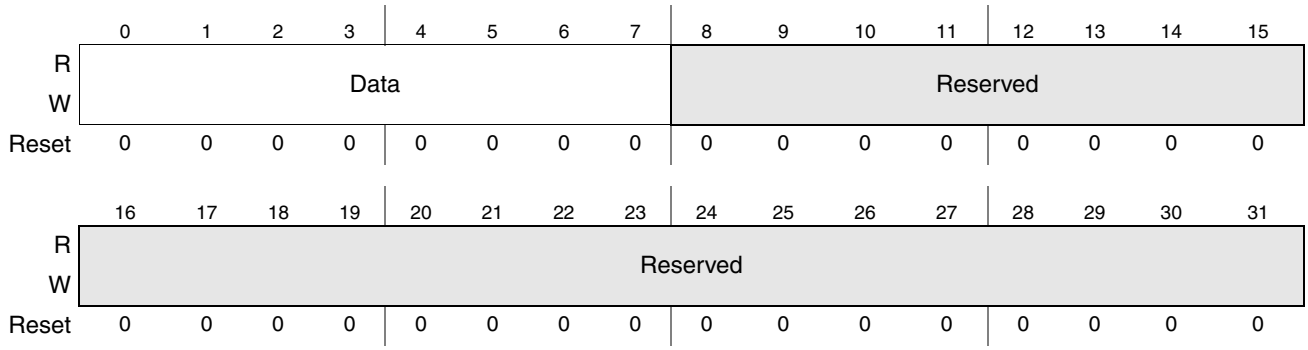



**Figure 11-27. ATA Drive Cylinder Low Register**

**Table 11-26. ATA Drive Cylinder Low Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | Data | Bit content is command dependent. For most commands, this register indicates the data transfer starting sector number for when CHS addressing is enabled. This register indicates part of the LBA address when the LBA addressing is enabled.<br>Register is written only when ATA drive status register bits BSY and DRQ equal 0 and $\overline{\text{DMACK}}$ is not asserted. If this register is written when BSY and DRQ bits are set to 1, the result is indeterminate.<br>Register content is not valid when drive is in sleep mode. |
| 8:31 | — | Reserved |

### 11.3.3.9 ATA Drive Cylinder High Register

Address MBAR + 0x3A74

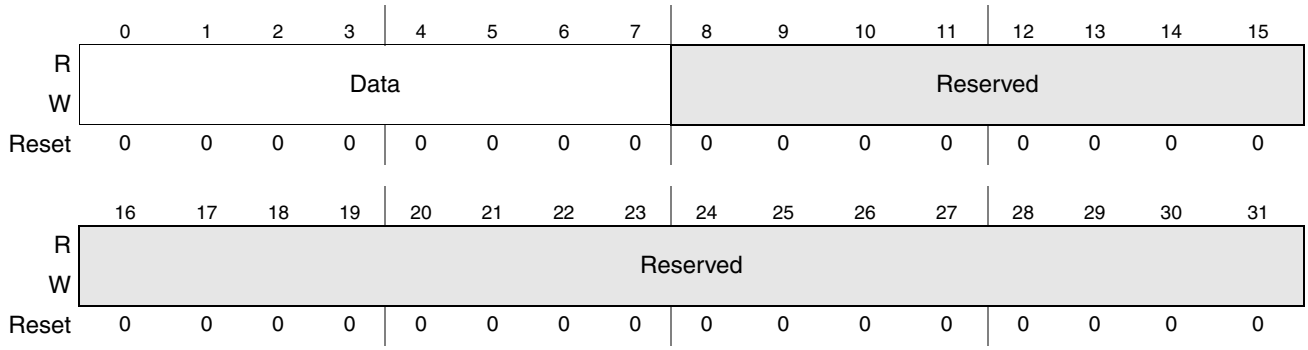



**Figure 11-28. ATA Drive Cylinder High Register**

**Table 11-27. ATA Drive Cylinder High Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | Data | Bit content is command dependent. For most commands, this register indicates the data transfer starting sector number for when CHS addressing is enabled. This register indicates part of the LBA address when the LBA addressing is enabled.<br>This register is written only when ATA drive status register bits BSY and DRQ equal 0 and $\overline{\text{DMACK}}$ is not asserted. If this register is written when BSY and DRQ bits are set to 1, the result is indeterminate.<br>Register content is not valid when drive is in sleep mode. |
| 8:31 | — | Reserved |

## 11.3.3.10 ATA Drive Device/Head Register

Address MBAR + 0x3A78

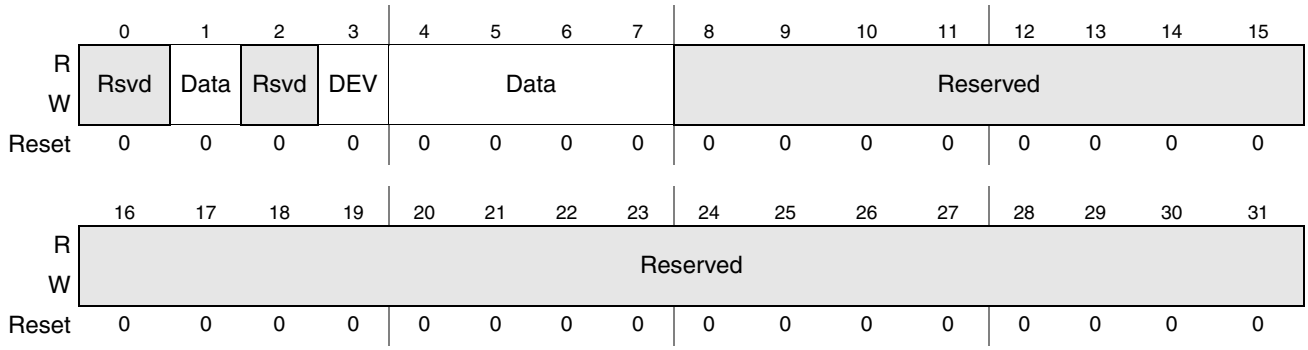



**Figure 11-29. ATA Drive Device/Head Register**

**Table 11-28. ATA Drive Device/Head Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | — | Reserved |
| 1 | Data | Bit is command dependent. In LBA addressing mode, this bit is set to 1 to indicate LBA addressing is chosen for data transfer. |
| 2 | — | Reserved |
| 3 | — | Reserved |
| 4:7 | Data | Bit content is command dependent. For most commands, this register indicates the data transfer starting sector number for when CHS addressing is enabled. This register indicates part of the LBA address when the LBA addressing is enabled.<br>This register is written only when ATA drive status register bits BSY and DRQ equal 0 and $\overline{\text{DMACK}}$ is not asserted. If this register is written when BSY and DRQ bits are set to 1, the result is indeterminate.<br>Register content is not valid when drive is in sleep mode. |
| 8:31 | — | Reserved |

## 11.3.3.11 ATA Drive Device Command Register

Address MBAR + 0x3A7C

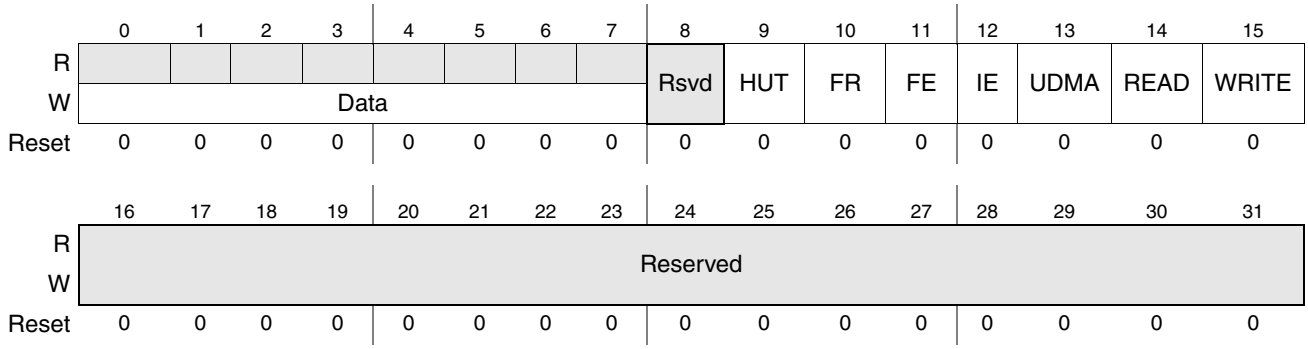



**Figure 11-30. ATA Drive Device Command Register**

**Table 11-29. ATA Drive Device Command Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | Data | Register contains the command code sent to the drive. When this register is written, command execution begins immediately. Writing this register clears any pending interrupt condition. |
| 8 | — | Reserved |
| 9 | HUT | Host UDMA burst Terminate—Software can terminate UDMA burst prematurely by setting this bit. Bits 15 through 10 are unaffected and retain previous values. |
| 10 | FR | FIFO Reset—Hardware resets FIFO when the direction is switched from Tx to Rx. No hardware reset is done for Rx to Tx switch. Software must verify FIFO is empty before filling it for Tx. When bit 10 is set, FIFO is being reset and bits 15, 14, 13, 12, 11, 9 and 8 are invalid. |
| 11 | FE | Enable FIFO flush in Rx mode—For all commands except DEVICE RESET, this register is written only when the ATA drive status register bits BSY and DRQ equal 0 and DMACK is not asserted. If this register is written when BSY or DRQ bits are set to 1, the result is indeterminate except for the DEVICE RESET command.<br>Register content is not valid when drive is in sleep mode. |
| 12 | IE | Enables drive interrupt to pass to CPU in DMA/UDMA modes. Software writes to this register as follows:<br>• FE (bit 11) and IE (bit 12)<br>• Clear IE and set FE if SDMA task loop count is the same as the data transfer requested from the drive.<br>The following is a typical sequence if the BestComm task loop is a larger count than data request programmed for the drive:<br>1. Start transaction with IE set and FE cleared.<br>2. Repeat until task loop count expires.<br>3. Start last transaction with IE clear and FE set.<br>• Controller issues flush at end.<br>• Task loop completes and interrupts CPU.<br>• CPU responds to SDMA interrupt instead of drive interrupt.<br>• UDMA (bit 13)—Set when UDMA protocol is selected for data transfer, cleared for DMA protocol.<br>• READ (bit 14)—Set when read command for DMA/UDMA protocols is written to drive command register, cleared otherwise.<br>• WRITE (bit 15)—Set when write command for DMA/UDMA protocols is written to drive command register, cleared otherwise.<br>**MANDATORY—Be Aware:** Drive interrupt must be enabled by clearing bit 1 of drive control register for DMA/UDMA mode transfers. |
| 13 | UDAMA | Bit is set when UDMA protocol is selected, cleared when multiword DMA protocol is selected. |
| 14 | READ | Bit is set when READ DMA command is issued. |
| 15 | WRITE | Bit is set when WRITE DMA command is issued. |
| 16:31 | — | Reserved |

### 11.3.3.12 ATA Drive Device Status Register

Address MBAR + 0x3A7C

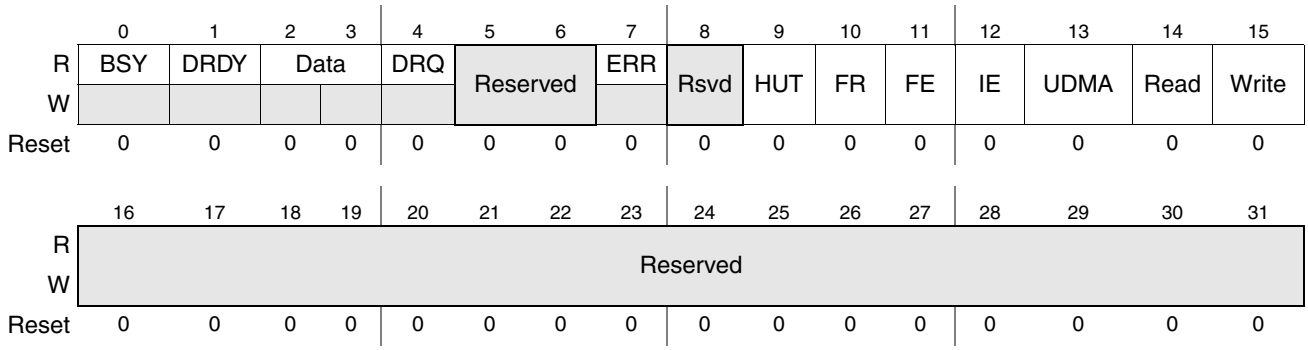



**Figure 11-31. ATA Drive Device Status Register**

**Table 11-30. ATA Drive Device Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | BSY | Indicates drive is busy processing a command. |
| 1 | DRDY | Indicates drive is ready to accept executable commands. |
| 2:3 | Data | Command dependent—Register is written only when ATA drive status register bits BSY and DRQ equal 0 and $\overline{\text{DMACK}}$ is not asserted. If this register is written when BSY and DRQ bits are set to 1, the result is indeterminate.<br>Register content is not valid when drive is in sleep mode. |
| 4 | DRQ | Indicates drive is ready to transfer a data word. |
| 5:6 | — | Reserved |
| 7 | ERR | Set to 1 indicates ATA drive error register bits are valid. |
| 8 | — | Reserved |
| 9 | HUT | Host UDMA burst Terminate—Software can terminate UDMA burst prematurely by setting this bit. Bits 15 through 10 are unaffected and retain previous values. |
| 10 | FR | FIFO Reset—Hardware resets FIFO when the direction is switched from Tx to Rx. No hardware reset is done for Rx to Tx switch. Software must verify FIFO is empty before filling it for Tx. When bit 10 is set, FIFO is being reset and bits 15, 14, 13, 12, 11, 9 and 8 are invalid. |
| 11 | FE | Enable FIFO flush in Rx mode—For all commands except DEVICE RESET, this register is written only when the ATA drive status register bits BSY and DRQ equal 0 and DMACK is not asserted. If this register is written when BSY or DRQ bits are set to 1, the result is indeterminate except for the DEVICE RESET command.<br>Register content is not valid when drive is in sleep mode. |

**Table 11-30. ATA Drive Device Status Register Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 12 | IE | Enables drive interrupt to pass to CPU in DMA/UDMA modes. Software writes to this register as follows:<br>• FE (bit 11) and IE (bit 12)<br>• Clear IE and set FE if SDMA task loop count is the same as the data transfer requested from the drive.<br>The following is a typical sequence if the SDMA task loop is a larger count than data request programmed for the drive:<br>1. Start transaction with IE set and FE cleared.<br>2. Repeat until task loop count expires.<br>3. Start last transaction with IE clear and FE set.<br>• Controller issues flush at end.<br>• Task loop completes and interrupts CPU.<br>• CPU responds to BestComm interrupt instead of drive interrupt.<br>• UDMA (bit 13)—Set when UDMA protocol is selected for data transfer, cleared for DMA protocol.<br>• READ (bit 14)—Set when read command for DMA/UDMA protocols is written to drive command register, cleared otherwise.<br>• WRITE (bit 15)—Set when write command for DMA/UDMA protocols is written to drive command register, cleared otherwise.<br>**MANDATORY—Be Aware:** Drive interrupt must be enabled by clearing bit 1 of drive control register for DMA/UDMA mode transfers. |
| 13 | UDAMA | Bit is set when UDMA protocol is selected, cleared when multiword DMA protocol is selected. |
| 14 | READ | Bit is set when READ DMA command is issued. |
| 15 | WRITE | Bit is set when WRITE DMA command is issued. |
| 16:31 | — | Reserved |

## 11.4 ATA Host Controller Operation

With the asynchronous ATA interface, an interface must be implemented that meets the timing specifications, given an input clock from the processor that is not fixed among all applications. The challenge is to meet the minimum ATA specifications while minimizing wasted time. Time is wasted because of differences between the minimum specification and the number of clock-cycles, multiplied by the clock-cycle period. This indicates the counter compare value depends on:

- The data transfer mode
- The clock frequency driving the ATA state machine (IPB clock)
- The minimum data transfer mode cycle-time passed in the INDENTIFY block from the drive to the ATA Host Controller

Software requirements for setting up the Host Controller are as follows:

1. Write into ata_config register to enable (ata_config[7] == 1) support for IORDY for PIO modes 3 and 4.
2. Software determines ATA mode timing based on the operating clock frequency

$$\text{Count} = \frac{\text{ATA\_mode\_timing\_spec} + \text{ipbi\_clock\_period} - 1}{\text{clock\_period}}$$

   This rounds up to the smallest integer number of clock counts that meet the minimum specification.

   In the case of counters that control duration of a read strobe (pio_t2_8, pio_t2_16 and dma_td), the added transceiver propagation delay must be taken into account so the read data meets setup time to the rising edge of the strobe. Therefore:

$$\text{Count} = \frac{\text{ATA\_mode\_timing\_spec} + 2 \times \text{XCVR\_PROP\_DLY} + \text{clock\_period} - 1}{\text{clock\_period}}$$

   udma_t2cyc is another special case. Unlike the name implies, this register does not control 2 UDMA timing cycles. Rather, it controls how long the host continues to accept data after it has de-asserted HDMARDY–. According to the ATA-4 specification—if tSR is met, the host should accept 0–1 more data words, or if tSR is exceeded, 0–2 more data words. A safe value to ensure the host accepts these data words after HDMARDY– de-asserts is:

$$\text{Count} = \frac{4 + \text{t2CYC\_sec[mode]} + \text{clock\_period} - 1}{\text{clock\_period}}$$

3. Write the calculated count in the timing registers provided in the ATA host register memory map.
4. Write ATA drive registers per ATA-4 specification using Host Controller register memory map to the setup drive for desired operation.
5. Read/Write to unimplemented registers or read of a write-only or vice versa errors set flag bits in the ATA Host Controller status register. The status register is cleared by writing 1 to the flag bit set to indicate an error.
6. Write ata_dma_mode register to indicate UDMA/DMA READ/WRITE operations for UDMA/DMA data transfer modes.
7. Initiate and complete data transfers according to protocols described in ATA-4 specification.

ATA host hardware does data transfers per chosen protocol. Hardware also maintains proper handshaking with the MPC5200B system.

The ATA state machine is a combination of several small state machines. The data transfers is initiated by the software. The software chooses the mode of operation and sets up needed registers in the ATA Host Controller IPBI module.

The ATA drive registers are also set up by the software through ATA IPBI module using PIO mode. The ATA drive command and control block registers are mapped into ATA Host Controller register memory map.

The software writes a command to be executed in the ATA drive command register. The command code is decoded by the drive electronics. The software, at the same time indicates to the host if UDMA/DMA protocol is used for READ/WRITE of the data. This is done by setting proper bits in the ata_dma_mode register in the ATA IPBI module.

### 11.4.1 PIO State Machine

In the ATA-4 spec, 16 timing characteristics must be met for a PIO data or register access:

- 9 are driven by the ATA drive controller—2 (t1 and ta) are counted by the Host Controller for checking/latching purposes.
- 7 are driven by the ATA Host Controller

To simplify Host Controller design, the following implementation is used:

- Counter—The counter used to count this timing spec (pio_<name>_counter). All non-zero counters count down from an initial value to 1 (end)
- Start from—Where this counter is initialized.
- Activity at end—What activity to perform when counter reaches 1
- Dependencies—When counter reaches 0, what signals must be checked before counter is finished (cleared to 0)

**Table 11-31. PIO Timing Requirements**

| Counter | Start from | Activity at end | Dependencies |
|---|---|---|---|
| t0 | t1 | go to IDLE | t2=0, t2i=0, t4=0 |
| t1[1] | N/A (Use t1 instead) | — | — |
| t2 | t1 | Latch Read_Data | IORDY_reg=1 |
| t2i | t2 | — | — |
| t3[2] | N/A (Use t2 instead) | — | — |
| t4 | t3 | write_enable=0 | — |
| | | address_enable=0 | — |
| t5 | N/A (Timing controlled by drive controller) | — | — |
| t6 | N/A (Timing controlled by drive controller) | — | — |
| t6z | N/A (Timing controlled by drive controller) | — | — |

**Table 11-31. PIO Timing Requirements (continued)**

| Counter | Start from | Activity at end | Dependencies |
|---|---|---|---|
| t9[3] | N/A (Use t4 instead) | — | — |
| tA | t1 | Check IORDY | IORDY=1 |
| tB | N/A (Timing controlled by drive controller) | — | — |
| tC | N/A (Timing controlled by drive controller) | — | — |

1 Since t1 and t1 are both minimum specs, and t1 <= t1 for PIO modes 0–2, and t1 >= t1 for PIO modes 3–4, t1 is used to count both, by loading in an initial value that depends on the PIO mode being used. This is the responsibility of software.

2 Since t3 (WDATA setup time) is a minimum, and t3 <= t2 for all PIO modes, t2 is used to determine when to drive Write_Data on DD.

3 Since t4 and t9 are both minimum specs, and t4 >= t9 for all PIO modes, t4 is used to count from DIOR/DIOW negate to $\overline{CS}$[1]FX/$\overline{CS}$[3]FX/ADDR negate.

If ATA drive address space is accessed by CPU, the ATA IPBI module generates:

- a signal to enable the PIO mode state machine
- a wait state to the IPBI module to hold off any further IPBI module access

The PIO state machine indicates transfer is in progress to the IPBI module. This extends the transfer wait to the IPBI module until the PIO transaction is complete.

## 11.4.2 DMA State Machine

The interface between the ATA Controller DMA channel and the rest of the system is through a standard Type 1 BestComm FIFO interface. Table 11-32 shows the timing requirements specified in the ATA-4 spec for multiword DMA data transfers.

**Table 11-32. Multiword DMA Timing Requirements**

| Counter | Start from | Activity at end | Dependencies |
|---|---|---|---|
| TM | START (Negate CS0, CS1, set DMA_In_Progress flag) | Assert DMACK, Assert DIOR/DIOW, Write Data ready | DMARQ asserted by drive |
| TE | N/A (Timing controlled by drive controller) | — | — |
| TD | TM | Negate DIOR/DIOW, Latch Read Data/Drive Write Data | DMARQ=1 |
| TK | TD | Assert DIOR/DIOW | DMARQ=1 |
| TH | TD | Ready for new write data | DMARQ=1 |
| T0 | TD | Begin next cycle | DMARQ=1 |
| | | Start TJ, Start TN | DMARQ=0 |
| TJ | T0 | Negate DMACK, Go to Idle | DMARQ Negated, DMACK asserted, T0=0 |
| TN | T0 | Clear DMA_In_Progress flag. Allow CS0, CS1 to be driven | DMARQ Negated, DMACK asserted, T0=0 |

#### 11.4.2.1 Software Requirements

Software calculates the appropriate values of TD and TK based on information reported for the cycle time (T0) in the drive's IDENTIFY DEVICE data and the operating clock frequency. Cycle time (T0) must be greater than the sum of TD and TK.

## 11.5 Signals and Connections

**Table 11-33. MPC5200B External Signals**

| Signal | I/O | Description |
|---|---|---|
| DATA[15:0] | I/O | Data—16-bit Data Bus (DD pins on ATA cable). |
| SA[2:0] | O | Address—3-bit address, when combined with the two chip-selects, CS1FX and CS3FX, is used to address Control and Command Block Registers in an ATA drive controller (DA2, DA1 and DA0 on ATA cable, respectively). |
| $\overline{CS}$[1]FX | O | Chip select connected to $\overline{CS}$[0] on ATA cable. |
| $\overline{CS}$[3]FX | O | Chip select connected to $\overline{CS}$[1] on ATA cable. |
| IOW | O | I/O Write—Active low signal that denotes a WRITE transaction (DIOW on ATA cable). |
| IOR | O | I/O Read—Active low signal that denotes a READ transaction (DIOR on ATA cable). |
| DACK | O | DMA Acknowledge (DMACK on ATA cable). |
| INTRQ | O | ATA interrupt. |
| ATA_ISOLATION | O | ATA Write Enable to allow sharing of the ATA DD bus with PCI Bus. |
| IOCHRDY | I | I/O Channel Ready (IORDY pin on ATA cable) |
| DRQ | I | DMA Request (DMARQ pin on ATA cable) |
| RESET | NC[1] | Reset—Handled at the board level |

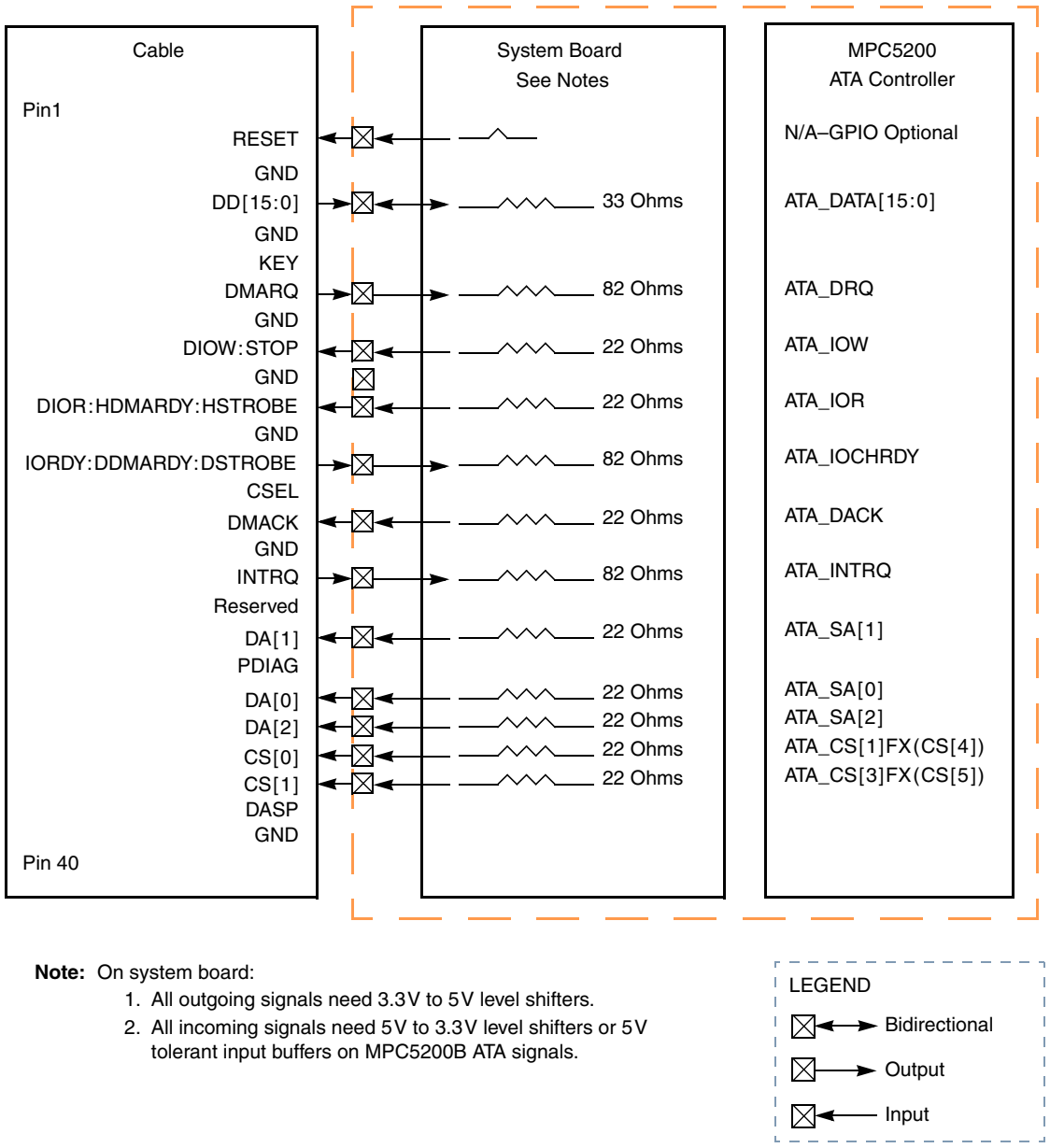
[1] NC = No connection

**NOTE**

The ATA_ISOLATION output is an active high signal to control external ATA transceiver devices and to isolate the ATA bus from the Local Plus (shared) bus. The ATA_ISOLATION pin is driven low immediately after the positive edge of HRESET for 4 PCI_CLK cycles.

This note is only a warning about the behavior of this pin.

Normally, the ATA_ISOLATION pin is used to control an isolation buffer between the LocalPlus Bus and the ATA bus. Even though this glitch will cause the ATA Isolation Buffer to drive the LocalPlus Bus for four PCI Clock Cycles, the LocalPlus Bus cannot initiate a bus cycle for approximately 10 cycles after the positive edge of HRESET. Therefore, bus conflict will not occur.




**Note:** On system board:

1. All outgoing signals need 3.3V to 5V level shifters.
2. All incoming signals need 5V to 3.3V level shifters or 5V tolerant input buffers on MPC5200B ATA signals.

**Figure 11-32. Connections—Controller Cable, System Board, MPC5200B**

## 11.6 ATA Interface Description

| Pin# | Cable | I/O | System Board | I/O | MPC5200B |
|---|---|---|---|---|---|
| 1 | RESET | O | $\overline{\text{RESET}}$:Reset | — | N/A—GPIO optional |
| 2 | GND | — | — | — | — |
| 3–18 | DD[15:0]<br>3,5,7,9,11,13,15,17→DD[7:0]<br>18,16,14,12,10,8,6,4→DD[15:8] | I/O | DD[0:15] | I/O | ATA_DATA[15:0] |
| 19 | GND | — | — | — | — |
| 20 | KEY | — | No Signal:Alignment key | — | — |
| 2 | DMARQ | I | DMARQ:DMA Request | I | ATA_DRQ |
| 22 | GND | — | — | — | — |
| 23 | $\overline{\text{DIOW}}$:STOP | O | DIOW | O | ATA_$\overline{\text{IOW}}$ |
| 24 | GND | — | — | — | — |
| 25 | $\overline{\text{DIOR}}$:$\overline{\text{HDMARDY}}$:HSTROBE | O | DIOR | O | ATA_$\overline{\text{IOR}}$ |
| 26 | GND | — | — | — | — |
| 27 | IORDY:$\overline{\text{DDMARDY}}$:DSTROBE | I | IORDY | I | ATA_IOCHRDY |
| 28 | CSEL | — | NC | — | — |
| 29 | DMACK | O | DMACK | O | ATA_$\overline{\text{DACK}}$ |
| 30 | GND | — | — | — | — |
| 31 | INTRQ | I | INTRQ | I | ATA_INTRQ |
| 32 | Reserved | — | — | — | — |
| 33 | DA[1] | O | DA[1]:Address Bus Bit1 | O | ATA_SA[1] |
| 34 | PDIAG | — | NC | — | — |
| 35 | DA[0] | O | DA[0]:Address Bus Bit0 | O | ATA_SA[0] |
| 36 | DA[2] | O | DA[2]:Address Bus Bit2 | O | ATA_SA[2] |
| 37 | CS[0] | O | $\overline{\text{CS}}$[1]$\overline{\text{FX}}$:Chip Select 0 | O | ATA_$\overline{\text{CS}}$[1]$\overline{\text{FX}}$($\overline{\text{CS}}$[4]) |
| 38 | CS[1] | O | $\overline{\text{CS}}$[3]$\overline{\text{FX}}$:Chip Select 1 | O | ATA_$\overline{\text{CS}}$[3]$\overline{\text{FX}}$($\overline{\text{CS}}$[5]) |
| 39 | DASP | — | NC | — | — |
| 40 | GND | — | — | — | — |

**Table 11-34. ATA Controller External Connections**

### NOTE

MPC5200B provides the ATA_ISOLATION output signal. This signal is shared with the A22 output of the LocalPlus Most/Graphics mode.

The ATA_ISOLATION is not a signal defined by the ATA Standard. It is provided to support an external ATA transceiver. ATA_ISOLATION is an active high signal to control external transceiver devices and to ‘isolate’ the ATA bus from the LocalPlus (shared) bus.

It can force the transceiver direction -> MPC5200 disk drive. Only during an ATA read is this signal allowed to go low, forcing transceiver direction disk drive ->MPC5200B.

The ATA_ISOLATION should be connected to the Direction input of the transceiver.

- High = Write to drive
- Low = Read from drive

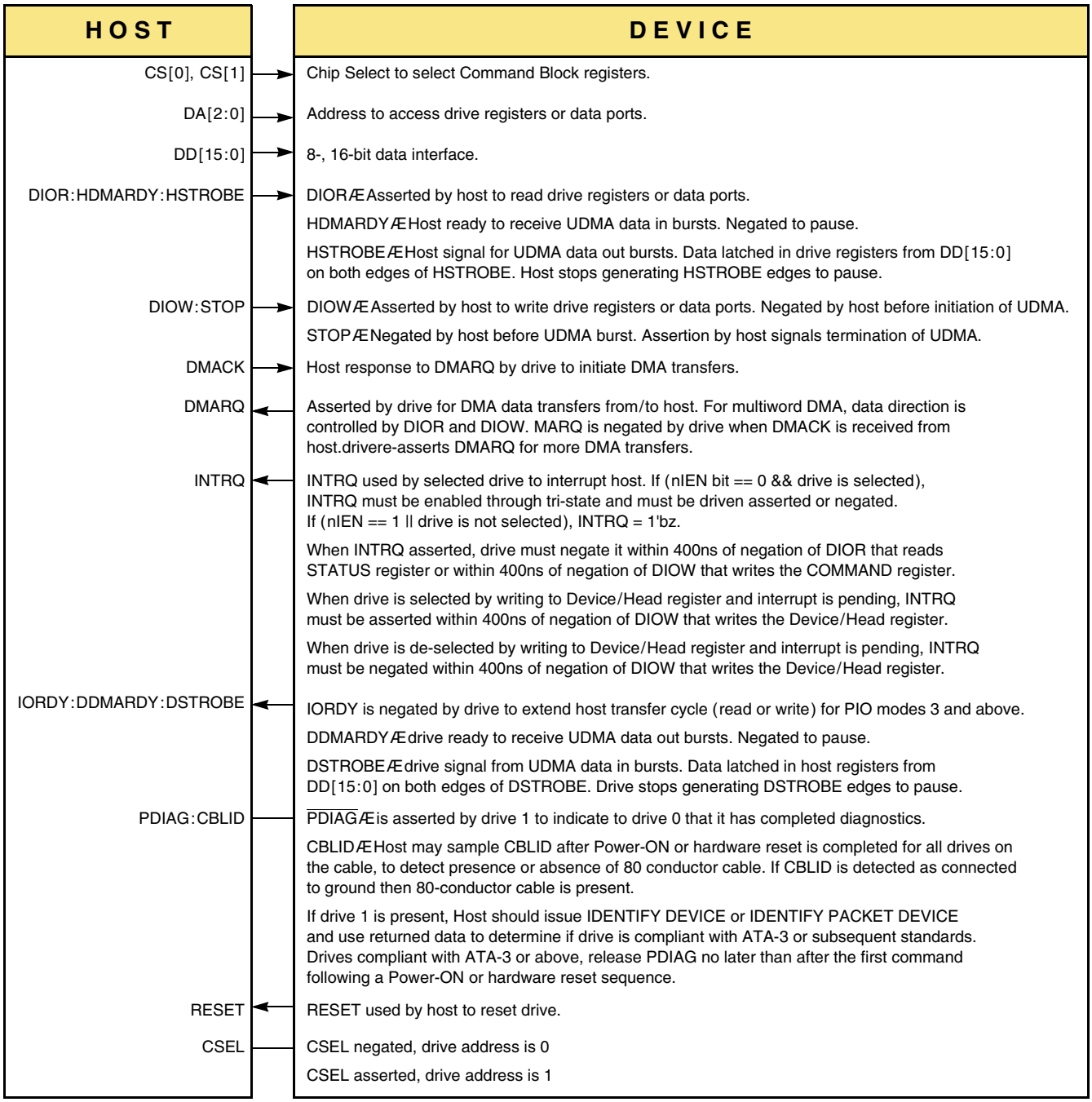

HOST
DEVICE
CS[0], CS[1]
Chip Select to select Command Block registers.
DA[2:0]
Address to access drive registers or data ports.
DD[15:0]
8-, 16-bit data interface.
DIOR:HDMARDY:HSTROBE
DIOR – Asserted by host to read drive registers or data ports.
HDMARDY – Host ready to receive UDMA data in bursts. Negated to pause.
HSTROBE – Host signal for UDMA data out bursts. Data latched in drive registers from DD[15:0] on both edges of HSTROBE. Host stops generating HSTROBE edges to pause.
DIOW:STOP
DIOW – Asserted by host to write drive registers or data ports. Negated by host before initiation of UDMA.
STOP – Negated by host before UDMA burst. Assertion by host signals termination of UDMA.
DMACK
Host response to DMARQ by drive to initiate DMA transfers.
DMARQ
Asserted by drive for DMA data transfers from/to host. For multiword DMA, data direction is controlled by DIOR and DIOW. MARQ is negated by drive when DMACK is received from host.drivere-asserts DMARQ for more DMA transfers.
INTRQ
INTRQ used by selected drive to interrupt host. If (nIEN bit == 0 && drive is selected), INTRQ must be enabled through tri-state and must be driven asserted or negated. If (nIEN == 1 || drive is not selected), INTRQ = 1'bz.
When INTRQ asserted, drive must negate it within 400ns of negation of DIOR that reads STATUS register or within 400ns of negation of DIOW that writes the COMMAND register.
When drive is selected by writing to Device/Head register and interrupt is pending, INTRQ must be asserted within 400ns of negation of DIOW that writes the Device/Head register.
When drive is de-selected by writing to Device/Head register and interrupt is pending, INTRQ must be negated within 400ns of negation of DIOW that writes the Device/Head register.
IORDY:DDMARDY:DSTROBE
IORDY is negated by drive to extend host transfer cycle (read or write) for PIO modes 3 and above.
DDMARDY – drive ready to receive UDMA data out bursts. Negated to pause.
DSTROBE – drive signal from UDMA data in bursts. Data latched in host registers from DD[15:0] on both edges of DSTROBE. Drive stops generating DSTROBE edges to pause.
PDIAG:CBLID
PDIAG – is asserted by drive 1 to indicate to drive 0 that it has completed diagnostics.
CBLID – Host may sample CBLID after Power-ON or hardware reset is completed for all drives on the cable, to detect presence or absence of 80 conductor cable. If CBLID is detected as connected to ground then 80-conductor cable is present.
If drive 1 is present, Host should issue IDENTIFY DEVICE or IDENTIFY PACKET DEVICE and use returned data to determine if drive is compliant with ATA-3 or subsequent standards. Drives compliant with ATA-3 or above, release PDIAG no later than after the first command following a Power-ON or hardware reset sequence.
RESET
RESET used by host to reset drive.
CSEL
CSEL negated, drive address is 0
CSEL asserted, drive address is 1

**Figure 11-33. Pin Description—ATA Interface**

# 11.7 ATA Bus Background

## 11.7.1 Terminology

The most popular interface used in modern hard disks is the Integrated Drive Electronics (IDE) interface, also known by various other names such as: ATA, EIDE, ATA-2, Fast ATA, Ultra ATA, etc.

- Western Digital® used the term IDE when they first integrated the drive controller logic board on the disk drive.
- Quantum® and Seagate® used the term ATA (Advanced Technology Attachment) or AT-Attachment, because it has a 16-bit data interface like original AT machines.

ATA is the interface name adopted by the American National Standards Institute (ANSI). Thus far, ANSI has published ATA, ATA-2, ATA-3 and ATA-4 interfaces. More work is underway for ATA-5 and future extensions of the ATA interface. Table 11-35 summarizes the different ATA standards.

MPC5200B is compliant with the latest officially published ANSI ATA-4 interface.

**Table 11-35. ATA Standards**

| Interface Standard | Standard Type | PIO Modes | DMA Modes | Special Features or Enhancements introduced Relative to IDE/ATA |
|---|---|---|---|---|
| IDE/ATA | ANSI | 0,1,2 | Single word—0,1,2<br>Multiword—0 | — |
| ATA-2 | ANSI | 0,1,2,3,4 | Single word—0,1,2<br>Multiword—0,1,2 | Block transfers, logical block addressing, improved identify drive command |
| FAST ATA | Marketing | 0,1,2,3 | Single word—0,1,2<br>Multiword 0,1 | Same as ATA-2 |
| Fast ATA-2 | Marketing | 0,1,2,3,4 | Single word—0,1,2<br>Multiword—0,1,2 | Same as ATA-2 |
| ATA-3 | Unofficial | 0,1,2,3,4 | Single word—0,1,2<br>Multiword—0,1,2 | Same as ATA-2, plus improved reliability, SMART |
| Ultra ATA | Unofficial | 0,1,2,3,4 | Single word—0,1,2<br>Multiword—0,1,2,3 | Same as ATA-3 |
| ATAPI | ANSI | 0,1,2,3,4 | Single word—0,1,2<br>Multiword—0,1,2 | Support for non-hard-disk devices CD-ROM, Tape drives, etc. |
| EIDE | Marketing | 0,1,2,3,4 | Single word—0,1,2<br>Multiword—0,1,2 | Same as ATA-2, plus ATAPI and dual host adapters |
| ATA-4 | ANSI | 0,1,2,3,4 | Multiword—0,1,2<br>Ultra DMA—0,1,2 | Same as ATA-3, Single word DMA retired |

## 11.7.2 ATA Modes

**Table 11-36. ATA Physical Level Modes**

| Mode | Cycle Time (ns) | Transfer Rate (MB/s) | Standard |
|---|---|---|---|
| PIO mode 0 | 600 | 3.3 | ATA |
| PIO mode 1 | 383 | 5.2 | ATA |
| PIO mode 2 | 240 | 8.3 | ATA |
| PIO mode 3 | 180 | 11.1 | ATA-2 (IORDY required) |
| PIO mode 4 | 120 | 16.7 | ATA-2 (IORDY required) |
| DMA mode 0 (Multiword) | 480 | 4.2 | ATA |
| DMA mode 1 (Multiword) | 150 | 13.3 | ATA-2 |
| DMA mode 2 (Multiword) | 120 | 16.7 | ATA-2 |
| Ultra DMA mode 0 | 114 | 16.7 | ATA-4 |
| Ultra DMA mode 1 | 75 | 25 | ATA-4 |
| Ultra DMA mode 2 | 55 | 33 | ATA-4 |

## 11.7.3 ATA Addressing

In the ATA interface, there are two aspects of addressing that are present: register addressing and sector addressing. These are discussed in the next sections.

### 11.7.3.1 ATA Register Addressing

The address used to reference an ATA drive register. This is the actual address ($\overline{CS}[1]\overline{FX}$, $\overline{CS}[3]\overline{FX}$, DA[2:0]) present on the physical ATA interface. Table 11-37 gives details.

**Table 11-37. ATA Register Address/Chip Select Decoding**

| Address | | | | | | Function | |
|---|---|---|---|---|---|---|---|
| System Address | CS[1]FX | CS[3]FX | DA[2] | DA[1] | DA[0] | READ ($\overline{DIOR}$) | WRITE ($\overline{DIOW}$) |
| | | | | | | Control Block Registers | |
| — | 1 | 1 | x | x | x | Data bus high impedance | Not used |
| 03F0–03F3 | 1 | 0 | 0 | x | x | Data bus high impedance | Not used |
| 03F4–03F5 | 1 | 0 | 1 | 0 | x | Data bus high impedance | Not used |
| 03F6 | 1 | 0 | 1 | 1 | 0 | Alternate status | Device control |
| 03F7 | 1 | 0 | 1 | 1 | 1 | Obsolete | Not used |
| | | | | | | Command Block Registers | |
| 01F0 | 0 | 1 | 0 | 0 | 0 | Data | Data |
| 01F1 | 0 | 1 | 0 | 0 | 1 | Error register | Features |
| 01F2 | 0 | 1 | 0 | 1 | 0 | Sector count | Sector count |
| 01F3 | 0 | 1 | 0 | 1 | 1 | Sector number | Sector number |
| 01F3 | 0 | 1 | 0 | 1 | 1 | LBA bits 0–7[1] | LBA bits 0–7[1] |

**Table 11-37. ATA Register Address/Chip Select Decoding (continued)**

| Address | | | | | | Function | |
|---|---|---|---|---|---|---|---|
| System Address | CS[1]FX | CS[3]FX | DA[2] | DA[1] | DA[0] | READ ($\overline{\text{DIOR}}$) | WRITE ($\overline{\text{DIOW}}$) |
| | | | | | | Control Block Registers | |
| 01F4 | 0 | 1 | 1 | 0 | 0 | Cylinder low | Cylinder low |
| 01F4 | 0 | 1 | 1 | 0 | 0 | LBA bits 8–15[1] | LBA bits 8–15[1] |
| 01F5 | 0 | 1 | 1 | 0 | 1 | Cylinder high | Cylinder high |
| 01F5 | 0 | 1 | 1 | 0 | 1 | LBA bits 16–23[1] | LBA bits 16–23[1] |
| 01F6 | 0 | 1 | 1 | 1 | 0 | Drive/head | Drive/head |
| 01F6 | 0 | 1 | 1 | 1 | 0 | LBA bits 24–27[1] | LBA bits 24–27[1] |
| 01F7 | 0 | 1 | 1 | 1 | 1 | Status | Command |
| — | 0 | 0 | x | x | x | Invalid address | Invalid address |

[1] LBA mode register mapping—system addresses are for a single channel, accommodating two drives only.

### 11.7.3.2 Drive Interrupt

A pending drive interrupt is cleared by the following actions:

- Read of status (not the alternate status) register
- Write to command register

### 11.7.3.3 Sector Addressing

Sector addressing is the address used to reference data on the drive. It is the address used by the low-level drivers to access a particular piece of data and to place it into one or more ATA registers as part of a command block. To understand the data addressing, it is necessary to understand the physical organization of data in a drive, as presented in Figure 11-1. Each drive contains a number of disks, each with one or two heads (one head per surface). Each disk is divided into concentric tracks that are then divided into a number of sectors. A sector is the smallest unit of data that can be written or read by a drive. The collections of tracks that can be accessed by the heads at a single position is called a cylinder. Therefore, a sector can be uniquely identified by a sector number, a head number and a cylinder number. From this addressing scheme there are two ways to address an individual sector: physical addressing and logical block addressing, which are described in the next two sections.

**NOTE**

LBA mode is only available in ATA-2 or later specifications.

A block mode exists (not to be confused with logical block addressing), in which sectors are grouped into a unit, called a block, for purposes of data transfer. The number of sectors is set with SET MULTIPLE MODE command and is used by the READ MULTIPLE and WRITE MULTIPLE commands. When specifying sectors within a block, either CHS or LBA mode may be used.

### 11.7.3.4 Physical/Logical Addressing Modes

Addressing is done by referencing the sector, head and cylinder for a particular sector. Using a physical addressing mode, there are two mappings available:

- Natural—Sector, head and cylinder numbers represent actual physical sectors, heads and cylinders on the drive.
- Logical—Sector, head and cylinder numbers map to different physical sectors, heads and cylinders on the drive.

Most modern hard disks usually have 2, 3 or 4 platters. All platters are connected together on a common spindle to spin as a single assembly. Each platter has two surfaces and two heads to access each surface. The platter is a collection of concentric circles called tracks, to store data. Each track is subdivided into sectors. Each sector can hold 540 Bytes of information, with 512 Bytes being used for data and 28 Bytes being used for error correction code (ECC). A set of tracks under each head at the same track position is called a cylinder. So to get to the disk read/write data point, a cylinder address, a head address and a sector address is needed. Hence the basic addressing mode is called cylinder head sector (CHS) addressing.

In this mode, the address is written into the ATA registers as follows:

- Cylinder → {Cylinder High (0x01F5), Cylinder Low (0x01F4)}
- Head → Drive/Head (0x01F6)
- Sector → Sector Number (0x01F3)

To most efficiently use the drive for data storage, the physical geometry is translated into logical geometry by the hard disk manufacturers. The BIOS or overlay software from the disk manufacturer translates the logical geometry to physical geometry to get to the physical location of the data written/read on/from the disk.

The CHS method is limited to 1024 cylinders, 16 heads and 63 sectors. This limits the hard disk recognition to a maximum of 504 MBytes. This limit is increased for larger disks by enhancing the CHS translation. BIOS limits cylinder size to 1024 (10 bits allocated), but allows the number of heads to be 256 (8 bits allocated). Therefore, a 3.1 GByte hard disk with 6136 cylinders and 16 heads is translated by dividing the cylinders by 8 (6136 ÷ 8 = 767). The number of heads is then multiplied by the same number (16 x 8 = 128). This fits well within the limits set by the BIOS and a larger disk is recognized for its true size (767 x 128 x 63 x 512 = 3.1 GBytes).

Another form of addressing is called logical block addressing (LBA). This uses 28 bits in the ATA standard to address a particular sector on a hard disk. A sum total of sectors on a drive is available and each unique sector is addressed using LBA.

Mapping from physical organization to logical block numbers is done using the following formula:

$$LBA \rightarrow (Cylinder\# \times HeadCount + Head\#) \times SectorCount + Sector\# - 1$$

In this mode, the address is written in the ATA Registers as follows:

LBA → {LBA[0:7](0x01F3), LBA[8:15](0x01F4), LBA[16:23](0x01F5), LBA[24:27] (0x01F6)}

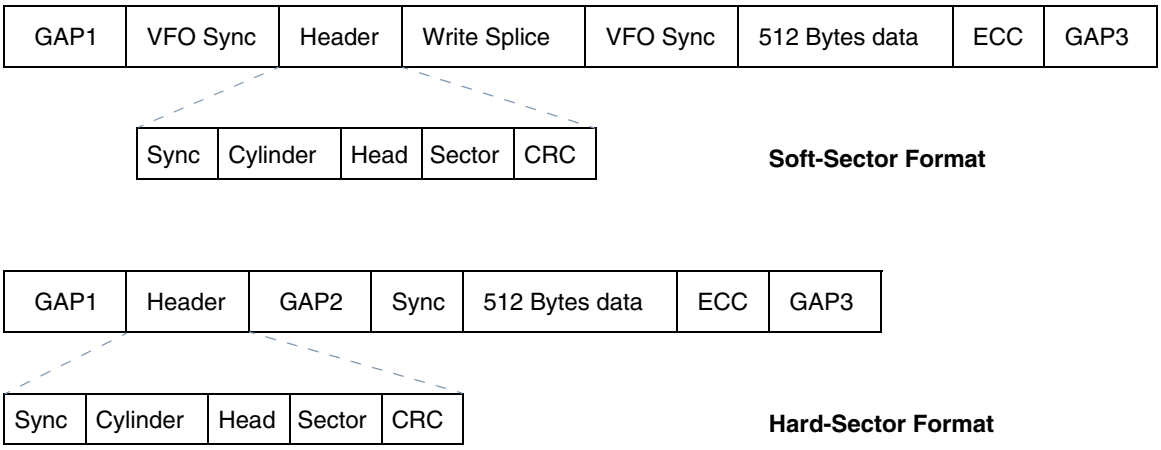



**Figure 11-34. ATA Sector Format**

## 11.7.4 ATA Transactions

ATA Transactions are divided into three types:

- PIO Mode
- Multiword DMA
- Ultra DMA

### 11.7.4.1 PIO Mode Transactions

PIO mode transactions are the simplest transaction available on the ATA interface. They essentially consist of single word accesses across the ATA interface. There are currently 6 PIO modes available, which are summarized in Table 11-36. Timing and sequence information are given in the MPC5200B data sheet.

Three classes of ATA commands use PIO Mode:

- Class 1—PIO Read
- Class 2—PIO Write
- Class Non-Data Command

#### 11.7.4.1.1 Class 1—PIO Read

Figure 11-35 shows the PIO Read process.

- PIO Single sector read [identify drive, read buffer, read sector(s)]
- Interrupt is generated after each sector is read into the sector buffer:

1. HOST: Write to ATA control/command block registers to setup for data read.
2. HOST: Write to ATA command register to execute read command.
3. HOST: Poll drive to see if it is ready.
4. DRIVE: Read sector from physical medium to sector buffer.
5. DRIVE: Interrupt HOST when done.
6. HOST: Read ATA control/command block registers to get status
7. DRIVE: Clear interrupt after reading status register.
8. HOST: Read ATA data register 256 times to get all 512 Bytes from sector buffer.
9. Repeat steps 4–8 for multiple sectors.

— PIO Block mode read [read multiple]
— Interrupt is generated after each block is read into sector buffer:

1. HOST: Write to ATA control/command block registers to setup for data read.
2. HOST: Write to ATA command register to execute read command.
3. HOST: Poll drive to see if it is ready.
4. DRIVE: Read block of sectors from physical medium to sector buffer.
5. DRIVE: Interrupt HOST when done.
6. HOST: Read ATA control/command block registers to get status.
7. DRIVE: Clear interrupt after reading status register.
8. HOST: Read ATA data register to get all sectors from sector buffer.

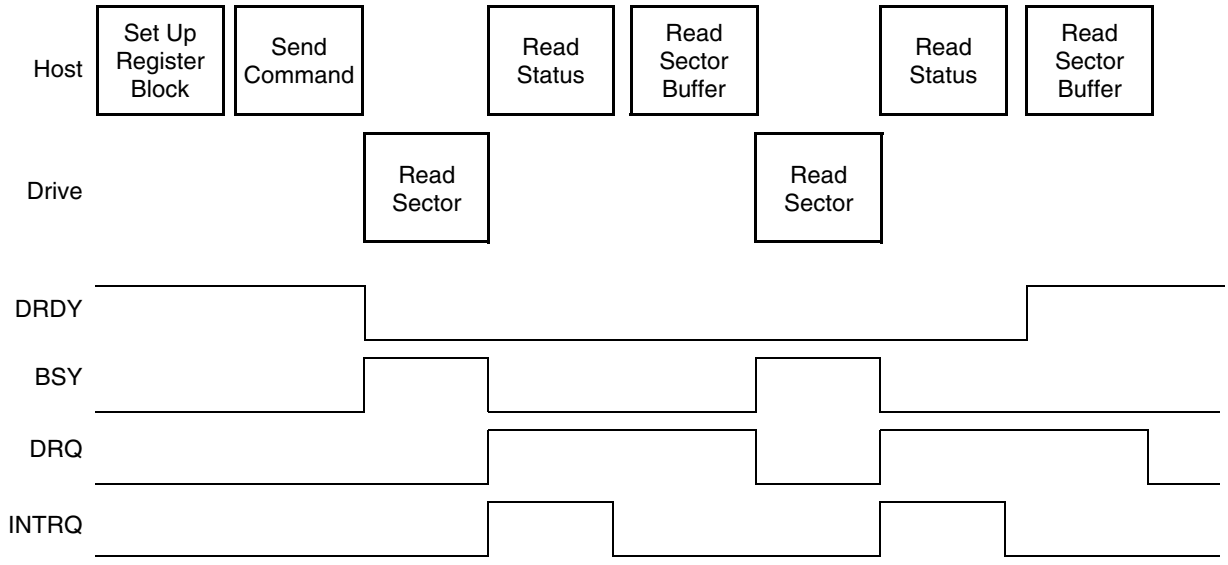



**Figure 11-35. Timing Diagram—PIO Read Command (Class 1)**

#### 11.7.4.1.2 Class 2—PIO Write

The PIO single sector write command [format, write buffer, write sector(s)] is as follows:

1. HOST: Write to ATA control/command block registers to setup for data write.
2. HOST: Write to ATA command register to execute write command.
3. HOST: Poll drive to see if it is ready.
4. HOST: Write ATA data register 256 times to get all 512 Bytes into sector buffer.
5. DRIVE: When sector buffer is filled, write sector to physical medium.
6. DRIVE: Interrupt HOST when done.
7. HOST: Read ATA control/command block registers to get status.
8. DRIVE: Clear interrupt after reading status register.
9. Repeat steps 4–8 for multiple sector writes.

The PIO block mode write command (write multiple) is as follows:

1. HOST: Write to ATA control/command block registers to set up for data write.
2. HOST: Write to ATA command register to execute write command.
3. HOST: Poll drive to see if it is ready.
4. HOST: Write ATA data register 256 times to get all sectors into sector buffer.
5. DRIVE: When sector buffer is filled, write sector to physical medium.
6. DRIVE: Interrupt HOST when done.
7. HOST: Read ATA control/command block registers to get status.
8. DRIVE: Clear interrupt after reading status register.

Figure 11-36 shows the PIO Write process.

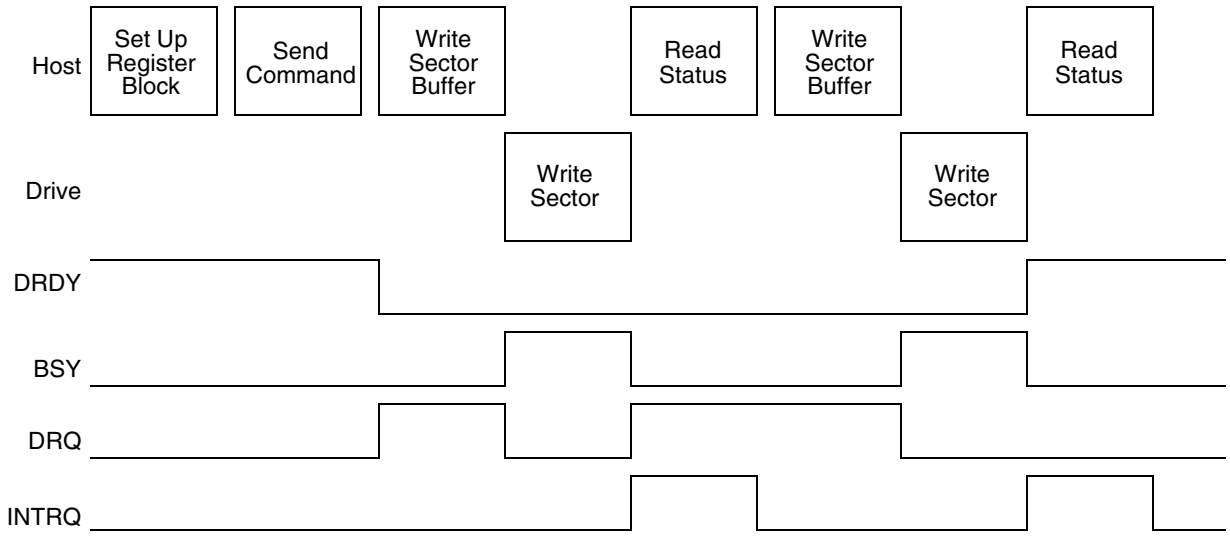



**Figure 11-36. Timing Diagram—PIO Write Command (Class 2)**

#### 11.7.4.1.3 Class 3—Non-Data Command

The Non-Data Command is as follows:

1. HOST: Write to ATA control/command block registers to setup for data read.
2. HOST: Write to ATA command register to execute read command.
3. DRIVE: Execute command.

Figure 11-37 shows the Non-Data Command.

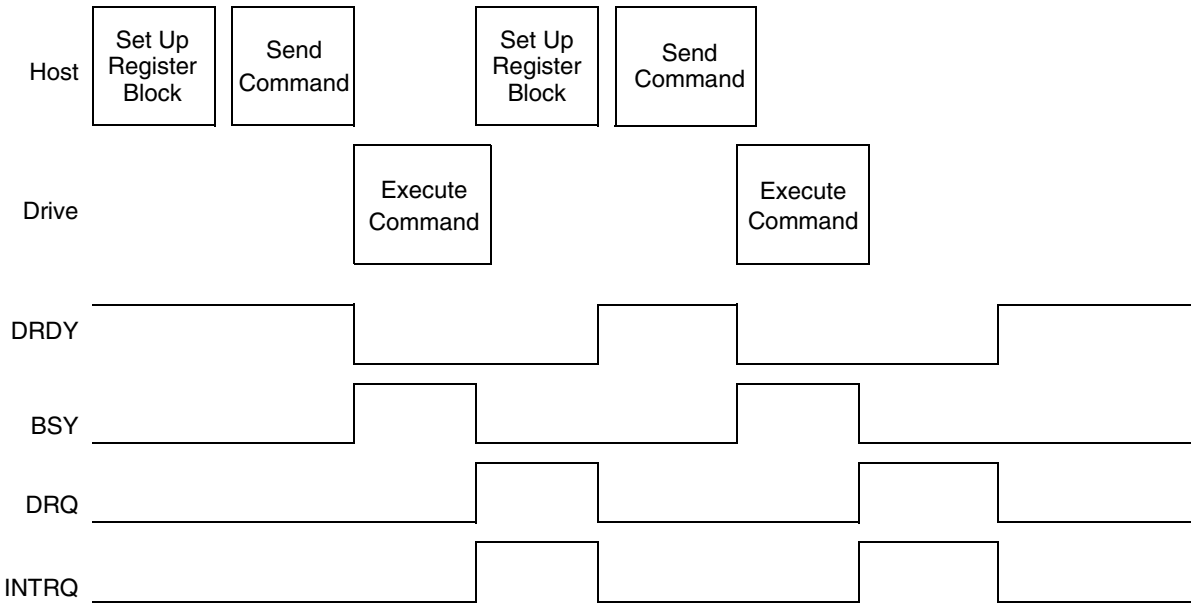



**Figure 11-37. Timing Diagram—Non-Data Command (Class 3)**

### 11.7.4.2 DMA Protocol

The DMA protocol has the following commands:

- READ DMA
- WRITE DMA

The Host selects the multiword DMA protocol as follows:

1. Write 00100b to upper 5 bits ([7:3]) of sector count register to select multiword DMA protocol. Write desired mode value to lower 3 bits ([2:0]) of sector count register to set multiword DMA transfer mode (mode 0=000b, mode 1=001b, etc.).
2. Write sub-command code 0x03 to features register to set transfer mode, based on value in sector count register.
3. Write command code 0xEF to command register to execute SET FEATURES command. This sets the data transfer protocol to multiword DMA with desired mode.

Data transfers into DMA differ from a PIO transfer in that:

- Data is transferred using the DMA channel.
- A single interrupt is issued at command completion.

The Host initializes the DMA channel prior to issuing DMA mode commands. The drive asserts an interrupt when data transfer is complete. The DMA command protocol is as follows:

1. HOST: Read status or alternate status register until BSY and DRQ are both 0. (ATA-4, 41, 48).
2. HOST: Write device/head register with appropriate DEV bit value to select drive. (ATA-4, 45).
3. HOST: Wait 400 ns, read status or alternate status register until BSY & DRQ are set to 0. The required drive is then assured to be selected.
4. HOST: Write required command parameters to the features, sector count, sector number, cylinder high, cylinder low, and device/head registers. (ATA-4, chapter 7).
5. HOST: Write command code to command register for drive to start processing command using parameters from the command block registers. (ATA-4, 41).
6. DRIVE: If no drive error exists, set BSY=1 and begin processing command.
7. HOST: Wait 400ns, read status or alternate status register to ensure valid contents.
8. DRIVE: Set BSY=1 or BSY=0 && DRQ=1.
9. DRIVE: Assert DMARQ when ready, transfer data per multiword DMA timing or ultra DMA protocol.
10. HOST: Assert DMACK, negate $\overline{CS}[0]$ and $\overline{CS}[1]$ when ready to transfer data per multiword DMA timing or ultra DMA protocol. Transfers are 16-bit wide from the data port. DMA data out (drive→host) transfers are processed by a series of reads to the data port. Each read transfers the data that follows the previous read. DMA in data (host→drive) transfers are processed by a series of writes to this port. Each write transfers the data that follows the previous write. Results are indeterminate if data port is written during a DMA data out or data port is read during a DMA data in transfers.

11. DRIVE: Negate DMARQ when transfer is complete.
12. DRIVE: Set error status in error register if error exists.
13. DRIVE: Clear BSY and DRQ.
14. DRIVE: Assert INTRQ if Host has enabled nIEN (set to 0) in command control register. This register is written by the host to enable interrupt from the drive by clearing nIEN bit to 0. INTRQ is in a high impedance state if nIEN bit is set to 1.

When host sets command control register bit SRST to 1, software can reset selected drive. However, the command control register must be written while DMACK is not asserted. Bit 0 must be cleared to 0.

1. HOST: To clear pending interrupt, read status register (regardless of nIEN status).
2. DRIVE: If enabled by nIEN (nIEN = 0), negate INTRQ.
3. DMA command completes.

**Table 11-38. DMA Command Parameters**

| DMA Command | Command Code | Parameters Used (Registers) | | | | |
|---|---|---|---|---|---|---|
| | | Features | Sector Count | Sector Number/LBA | Cylinder HI/LO/LBA | Device/Head/LBA |
| READ DMA | C8h | Yes | Yes | Yes | Yes | D/H Both |
| WRITE DMA | CAh | Yes | Yes | Yes | Yes | D/H Both |

Figure 11-38 shows the DMA command protocol flow diagram.

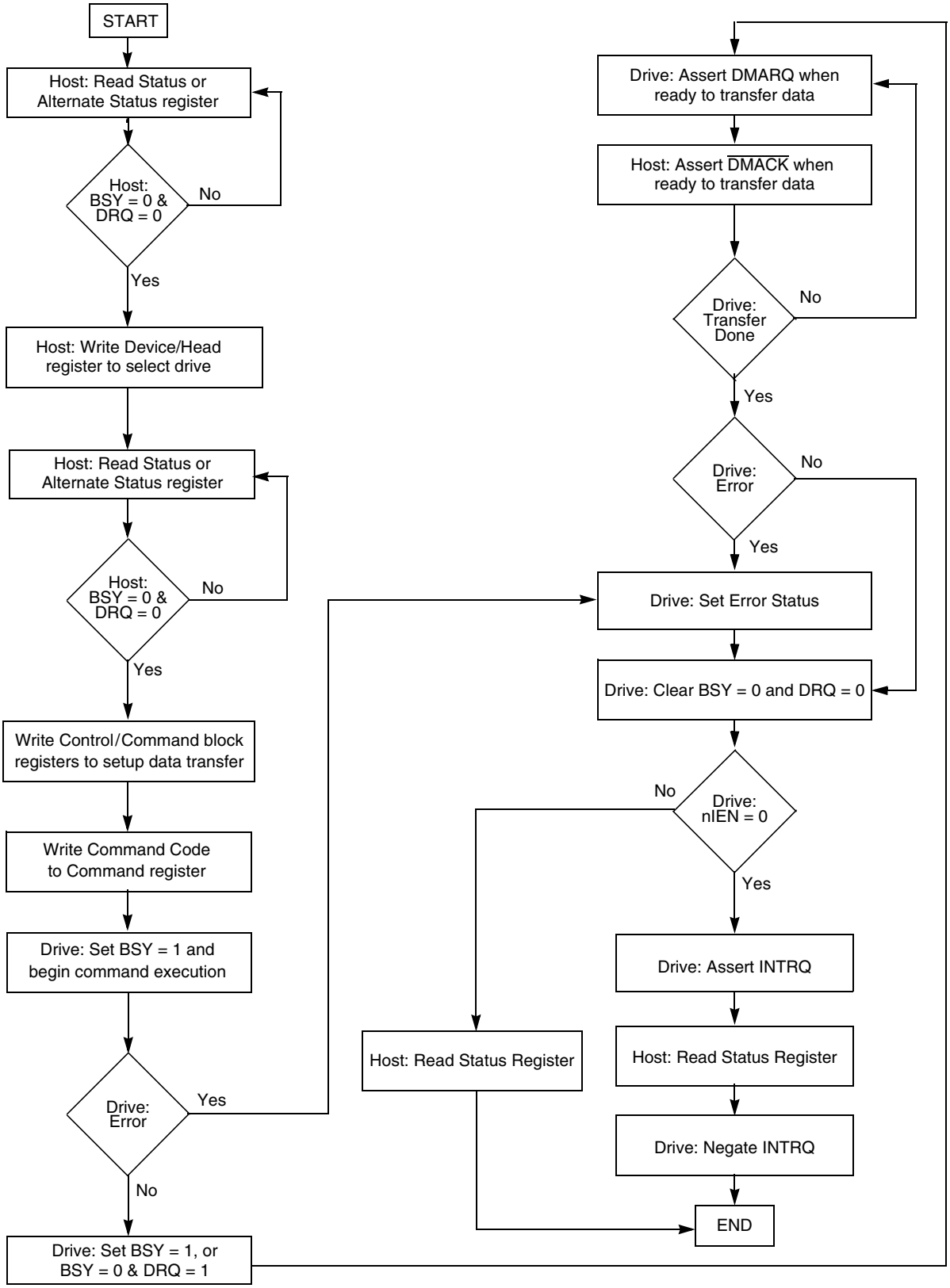

START
Host: Read Status or Alternate Status register
Host: BSY = 0 & DRQ = 0
No
Yes
Host: Write Device/Head register to select drive
Host: Read Status or Alternate Status register
Host: BSY = 0 & DRQ = 0
No
Yes
Write Control/Command block registers to setup data transfer
Write Command Code to Command register
Drive: Set BSY = 1 and begin command execution
Drive: Error
Yes
No
Drive: Set BSY = 1, or BSY = 0 & DRQ = 1
Drive: Assert DMARQ when ready to transfer data
Host: Assert DMACK when ready to transfer data
Drive: Transfer Done
No
Yes
Drive: Error
No
Yes
Drive: Set Error Status
Drive: Clear BSY = 0 and DRQ = 0
Drive: nIEN = 0
No
Yes
Drive: Assert INTRQ
Host: Read Status Register
Drive: Negate INTRQ
Host: Read Status Register
END

**Figure 11-38. Flow Diagram—DMA Command Protocol**

### 11.7.4.3 Multiword DMA Transactions

Multiword DMA transactions differ from PIO mode transactions in three ways:

1. Data transfers are done using a drive DMA and a host DMA (optional).
2. Handshaking is done with DMARQ and DMACK, no address is necessary.
3. Interrupts do not occur after every sector for multi-sector transfers

#### 11.7.4.3.1 Class 4—DMA Command

Figure 11-39 shows the DMA timing diagram. The DMA command (Read DMA, Write DMA) is as follows:

1. HOST: Set up HOST DMA (in ATA Host Controller or system DMA).
2. HOST: Write to ATA control/command block registers to setup drive DMA.
3. HOST: Write to ATA control/command block registers to set up data read/write.
4. HOST: Write to ATA command register to execute the read/write command.
5. DRIVE: Assert DMARQ.
6. HOST: When DMARQ is asserted, assert DMACK.
7. DRIVE: Read sector from physical medium to sector buffer.
8. DRIVE: Transfer data to HOST using DMA handshaking.
9. Repeat steps 7–8 as needed for multiple sectors.
10. DRIVE: De-assert DMARQ.
11. HOST: De-assert DMACK.
12. DRIVE: Interrupt HOST.
13. HOST: Stop HOST DMA.
14. HOST: Read ATA control/command block registers to get status.
15. DRIVE: Clear interrupt after reading status register.

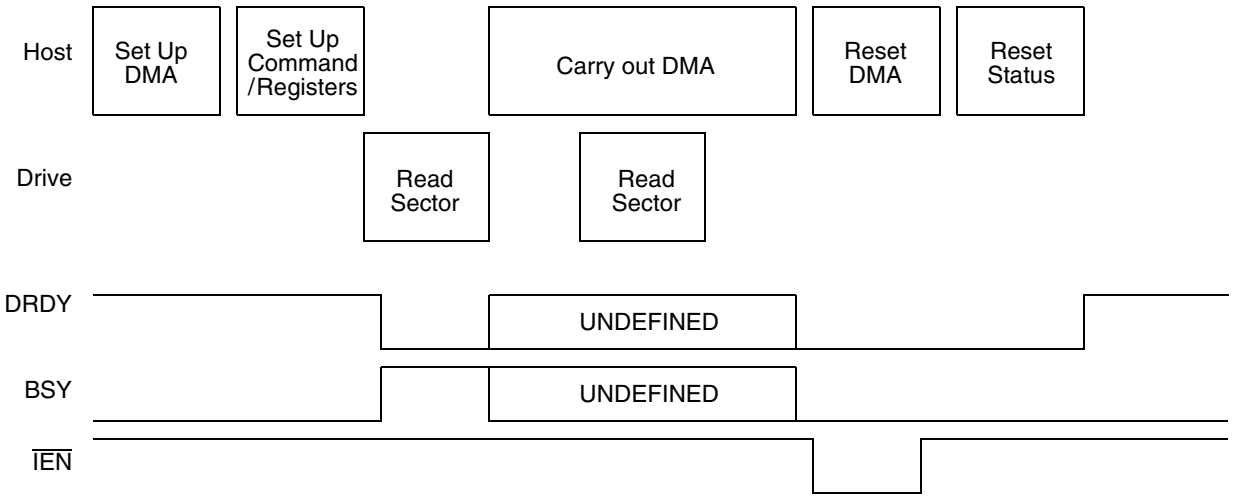



**Figure 11-39. Timing Diagram—DMA Command (Class 4)**

### 11.7.4.4 Ultra DMA Protocol

The Ultra DMA protocol has the following commands:

- READ DMA
- WRITE DMA

The host selects the Ultra DMA protocol as follows:

- Write 01000b to upper 5 bits ([7:3]) of sector count register to select ultra DMA protocol. Write desired mode value to lower 3 bits ([2:0]) of sector count register to set ultra DMA transfer mode (mode 0=000b, mode 1=001b, etc.).
- Write sub-command code 03h to features register to set transfer mode based on value in sector count register.
- Write command code EFh to command register to execute SET FEATURES command, which sets the data transfer protocol to ultra DMA with desired mode.

When enabled, the ultra DMA protocol is used instead of the multiword DMA protocol.

**NOTE**

Ultra DMA mode 2 (UDMA2) requires that the ip bus clock speed is at least 66MHz.

Table 11-39 lists the redefined ultra DMA protocol signal lines. These lines provide new functions during the ultra DMA mode. At termination of an ultra DMA burst, the host negates DMACK and the lines revert to the definitions used for non-ultra DMA transfers.

**Table 11-39. Redefinition of Signal Lines for Ultra DMA Protocol**

| Non-Ultra DMA Modes | Ultra DMA Modes | Description |
|---|---|---|
| DIOR | HDMARDY | Host DMA ready during Ultra DMA data in bursts |
| | HSTROBE | Host data strobe during Ultra DMA data out bursts |
| IORDY | DDMARDY | Drive DMA ready during Ultra DMA data out bursts |
| | DSTROBE | Drive data strobe during Ultra DMA data in bursts |
| DIOW | STOP | Host stop ultra DMA bursts |

Both the host and drive do a CRC function during an ultra DMA burst:

- The host sends CRC data to the drive.
- The drive does a CRC data comparison.

If the CRC comparison fails, the error register ERR bit is set. The drive always reports the first error that occurs.

## 11.8 ATA RESET/Power-Up

### 11.8.1 Hardware Reset

The host asserts $\overline{\text{RESET}}$ for a minimum of 25 µs after power has stabilized within system specified tolerance. A signal assertion less than 20 ns is not recognized by the drive.

The host should not do the following:

- set the device control register bit SRST to 1 to enable the drive for software reset
- issue a DEVICE RESET command while the status register BSY bit is set to 1.

**NOTE**

Hardware reset is a board requirement, not an MPC5200B function unless GPIO is used.

### 11.8.2 Software Reset

The host sets the device control register bit SRST to 1. Any subsequent setting and clearing of the SRST bit must be at least 5 µs apart.

Figure 11-40 shows the Reset timing diagram. Table 11-40 gives timing characteristics.

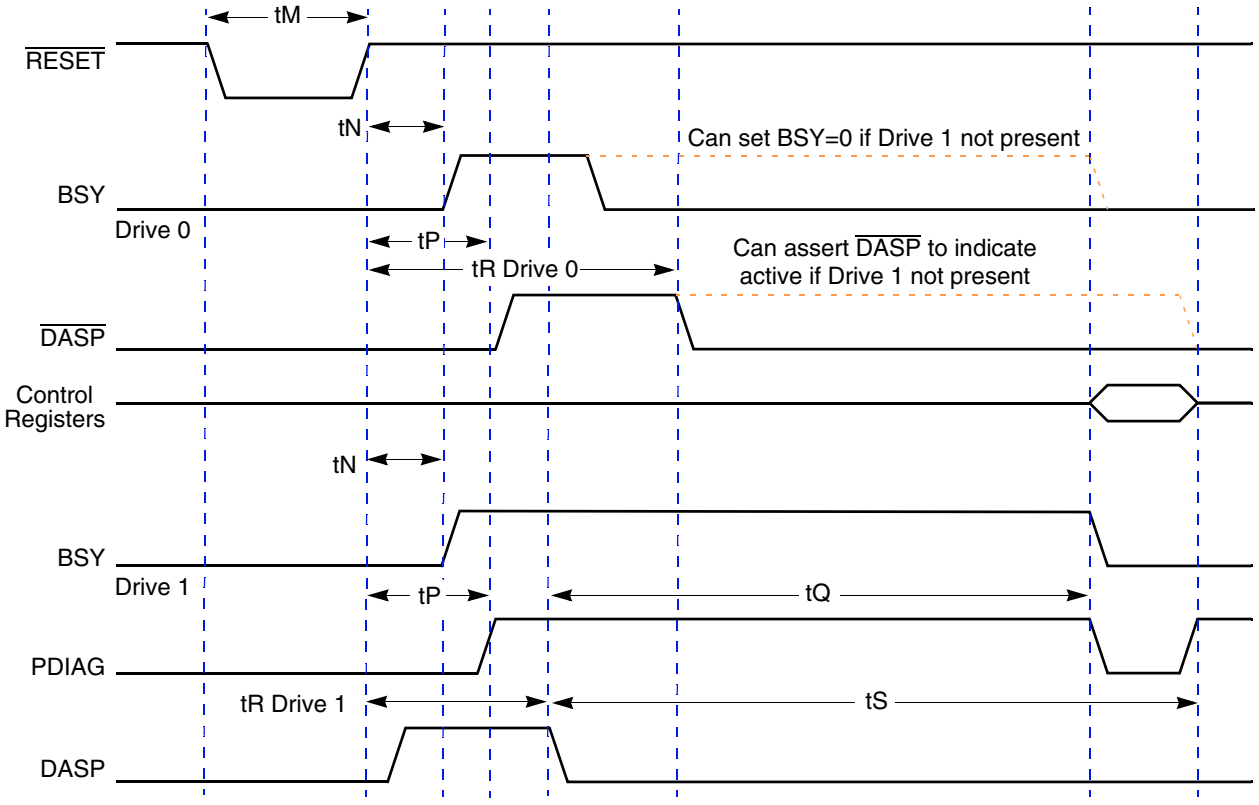



**Figure 11-40. Timing Diagram—Reset Timing**

**Table 11-40. Reset Timing Characteristics**

| Name | PIO Timing Parameter | Min/Max | Timing |
|---|---|---|---|
| tM | Reset pulse width | Min | 25µs |
| tN | Reset negated to BSY active setup | Max | 400ns |
| tP | Reset negated to $\overline{\text{DASP}}$ inactive setup | Max | 1ms |
| tQ | $\overline{\text{DASP}}$ active to $\overline{\text{PDIAG}}$ active setup | Max | 30s |
| tR | Drive 0—Reset negated to $\overline{\text{DASP}}$ active setup | Max | 450ms |
| | Drive 1—Reset negated to $\overline{\text{DASP}}$ active setup | Max | 400ms |
| tS | $\overline{\text{DASP}}$ active to $\overline{\text{PDIAG}}$ inactive setup | Max | 30.5s |

## 11.9 ATA I/O Cable Specifications

For reference, the standard ATA cable specifications affects stem integrity and should not exceed 18inches or 0.46m. Total cable capacitance should not exceed 35pF.

# Chapter 12
# Universal Serial Bus (USB)

## 12.1 Overview

The following sections are contained in this document:

- Section 12.2, “Data Transfer Types”
- Section 12.4, “Host Control (HC) Operational Registers”, includes:
  - Section 12.4.2, “Control and Status Partition”
  - Section 12.4.3, “Memory Pointer Partition”
  - Section 12.4.4, “Frame Counter Partition”
  - Section 12.4.5, “Root Hub Partition”

The Universal Serial Bus (USB) is an external bus standard that supports data transfer rates of 12 Mbps. Figure 12-1 shows the four main areas of a USB system, which are:

- Client software/USB driver—software implemented
- Host Controller Driver (HCD)—software implemented
- Host Controller (HC)—hardware implemented
- USB device—hardware implemented

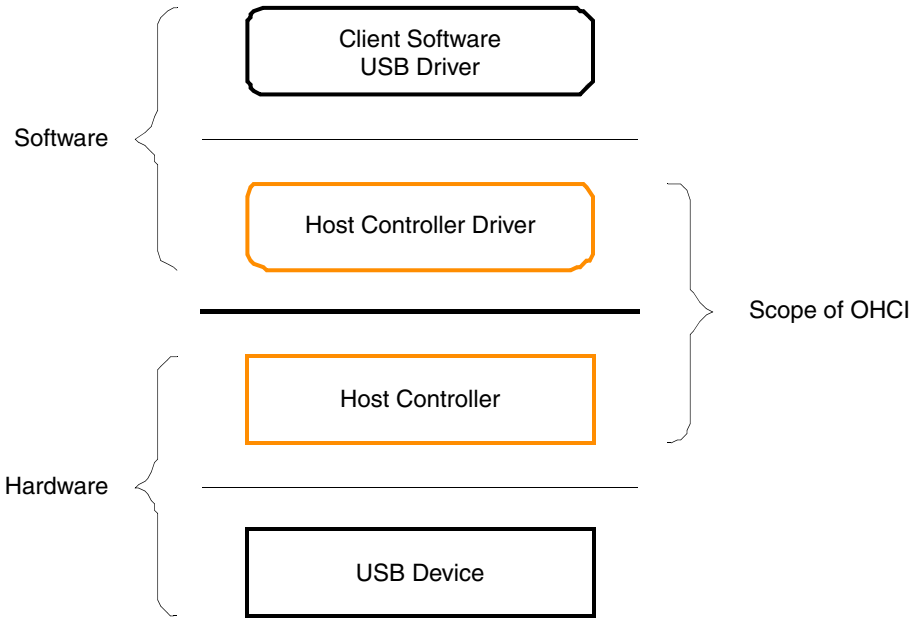



**Figure 12-1. USB Focus Areas**

The Open Host Controller Interface (OHCI) is a register-level description of a HC for the Universal Serial Bus (USB). OHCI specifies the interface between and the fundamental HCD operation and the HC.

The HCD and HC work in tandem to transfer data between client software and a USB device. Data is translated from shared-memory data structures at the client software end, to USB signal protocols at the USB device end, and vice-versa.

## 12.2 Data Transfer Types

Four data transfer types are defined in the USB. Each type is optimized to match the service requirements between client software and the USB device. These types are:

- **Interrupt Transfers**—Small data transfers used to communicate information from the USB device to the client software. The HCD polls the USB device by issuing tokens to the device at a periodic interval sufficient for the requirements of the device.
- **Isochronous Transfers**—Periodic data transfers with a constant data rate. Data transfers are correlated in time between the sender and receiver.
- **Control Transfers**—Non-periodic data transfers used to communicate configuration/command/status type information between client software and the USB device.
- **Bulk Transfers**—Non-periodic data transfers used to communicate large amounts of information between client software and the USB device.

In OpenHCI the data transfer types are classified into two categories: periodic and nonperiodic. Periodic transfers are interrupt and isochronous since they are scheduled to run at periodic intervals. Non-periodic transfers are control and bulk since they are not scheduled to run at any specific time, but rather on a time-available basis.

## 12.3 Host Controller Interface

### 12.3.1 Communication Channels

There are two communication channels between the HC and HCD.

1. The first channel uses a set of operational registers located on the HC. The HC is the target for all communication on this channel. The operational registers contain control, status, and list pointer registers. Within the operational register set is a pointer to a location in shared memory named the HC Communications Area (HCCA).
2. The HCCA is the second communication channel. The HC is the master for all communication on this channel. The HCCA contains the head pointers to the interrupt endpoint descriptor lists, the head pointer to the done queue, and status information associated with start-of-frame processing.

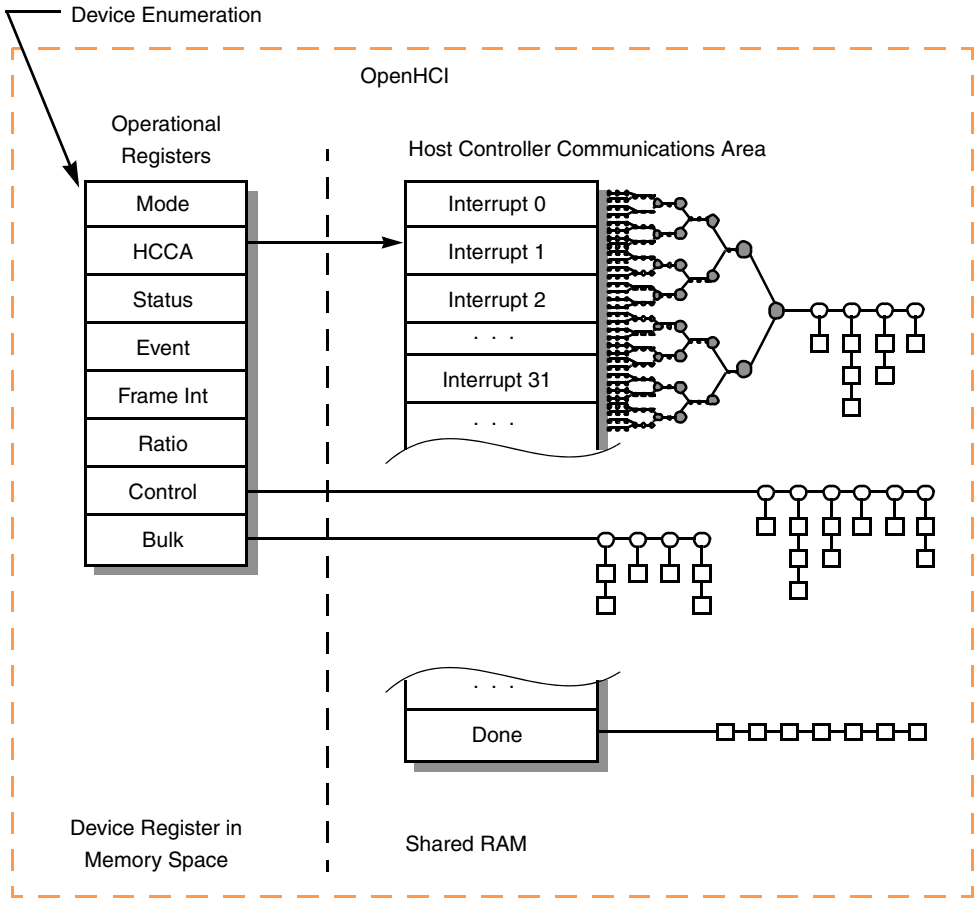



**Figure 12-2. Communication Channels**

## NOTE

The Open Host Controller Interface (OHCI) specification describes the Host Controller Communication Area (HCCA), which is located in memory (as opposed to the USB module register). The start address (base address) of that memory area is defined by the USB controller register HC Communication Register.

The HCCA includes the “virtual” registers HccaFrameNumber and HccaPad1. The offsets shall be 0x80 (for HccaFrameNumber) and 0x82 (for HccaPad1).

In the USB module of the MPC5200B these two “virtual” registers are swapped. The HccaFrameNumber is a copy of the Frame Number field at the USB HC Timing Reference Register.

## 12.3.2 Data Structures

The basic building blocks for communication across the interface are the endpoint descriptor (ED) and transfer descriptor (TD).

The HCD assigns an endpoint descriptor to each endpoint in the system. The endpoint descriptor contains the information necessary for the HC to communicate with the endpoint. The fields include the maximum packet size, the endpoint address, the speed of the endpoint, and the direction of data flow. Endpoint descriptors are linked in a list.

A queue of transfer descriptors is linked to the endpoint descriptor for the specific endpoint. The transfer descriptor contains the information necessary to describe the data packets to be transferred. The fields include data toggle information, shared memory buffer location, and completion status codes. Each transfer descriptor contains information that describes one or more data packets. The data buffer for each transfer descriptor ranges in size from 0 to 8192 Bytes with a maximum of one physical page crossing. Transfer descriptors are linked in a queue; the first one queued is the first one processed.

Each data transfer type has its own linked list of endpoint descriptors to be processed. Figure 12-3 shows the data structure relationship.

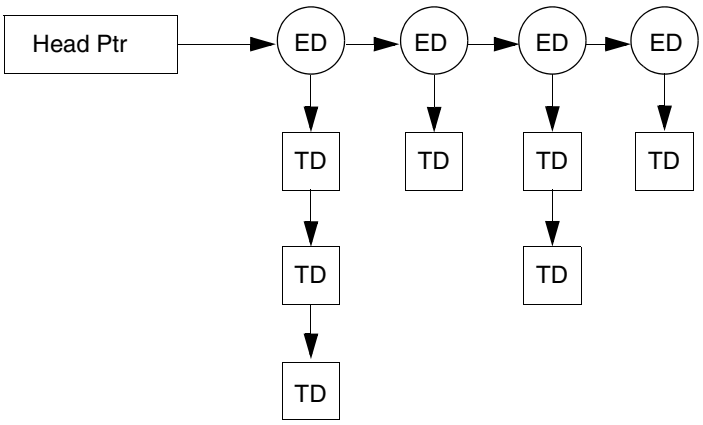



**Figure 12-3. Typical List Structure**

The head pointers to the bulk and control endpoint descriptor lists are maintained within the operational registers in the HC. The HCD initializes these pointers prior to the HC gaining access to them. Should these pointers need to be updated, the HCD may need to stop the HC from processing the specific list, update the pointer, then re-enable the HC.

The head pointers to the interrupt endpoint descriptor lists are maintained within the HCCA. There is no separate head pointer for isochronous transfers. The first isochronous endpoint descriptor simply links to the last interrupt endpoint descriptor. There are 32 interrupt head pointers. The head pointer used for a particular frame is determined by using the last five bits of the frame counter as an offset into the interrupt array within the HCCA.

The interrupt endpoint descriptors are organized into a tree structure with the head pointers being the leaf nodes. The desired interrupt endpoint polling rate is achieved by scheduling the endpoint descriptor at the appropriate depth in the tree. The higher the polling rate, the closer to the root of the tree the endpoint descriptor is placed. Figure 12-4 shows the interrupt endpoint structure. The Interrupt endpoint descriptor

placeholder indicates where zero or more endpoint descriptors may be queued. The numbers on the left are the index into the HCCA interrupt head pointer array.

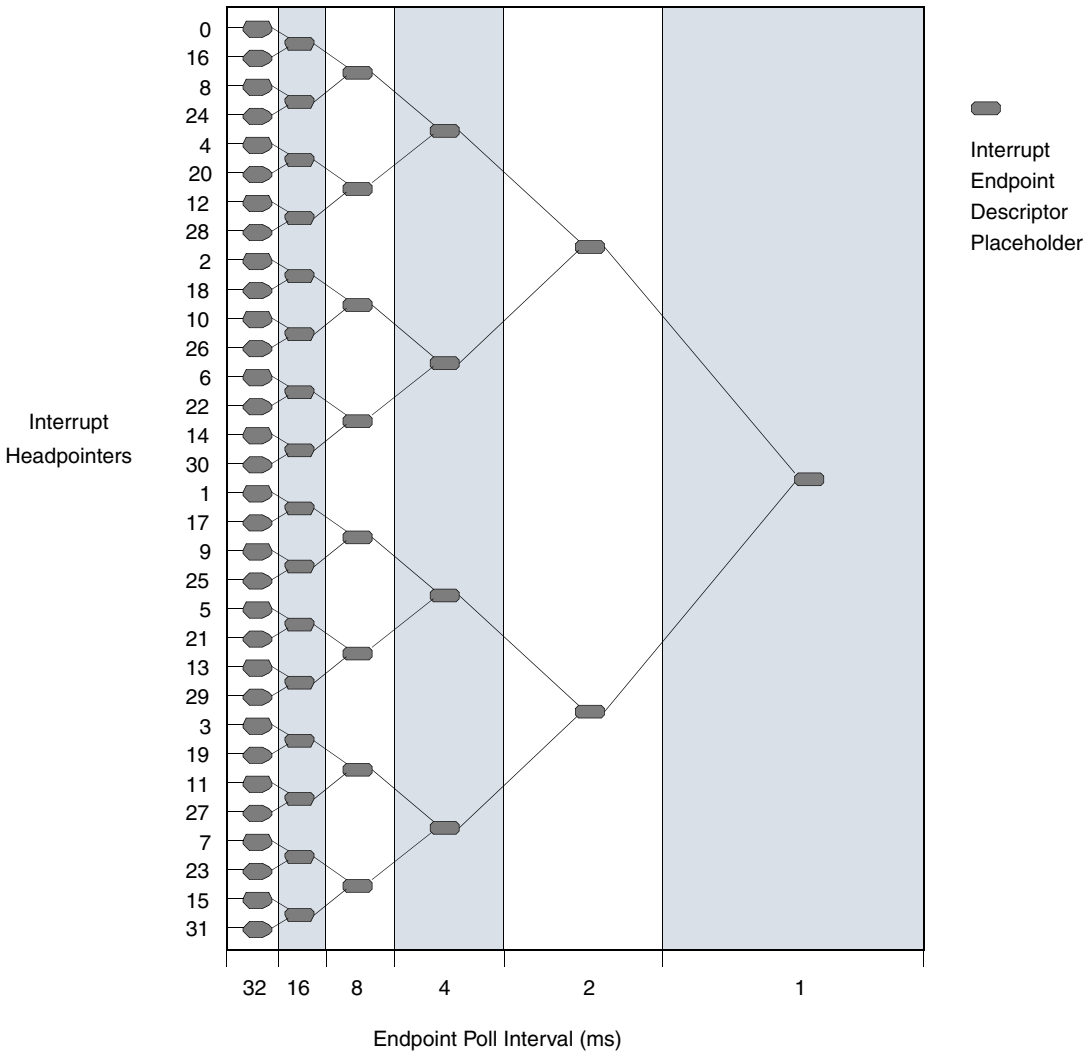



**Figure 12-4. Interrupt ED Structure**

Figure 12-5 shows a sample interrupt endpoint schedule. The schedule shows:

- Two endpoint descriptors at a 1ms poll interval
- Two endpoint descriptors at a 2ms poll interval
- One endpoint descriptor at a 4ms poll interval
- Two endpoint descriptors at an 8ms poll interval
- Two endpoint descriptors at a 16ms poll interval
- Two endpoint descriptors at a 32ms poll interval.

**NOTE**

Unused interrupt endpoint placeholders are bypassed and the link is connected to the next available endpoint in the hierarchy.

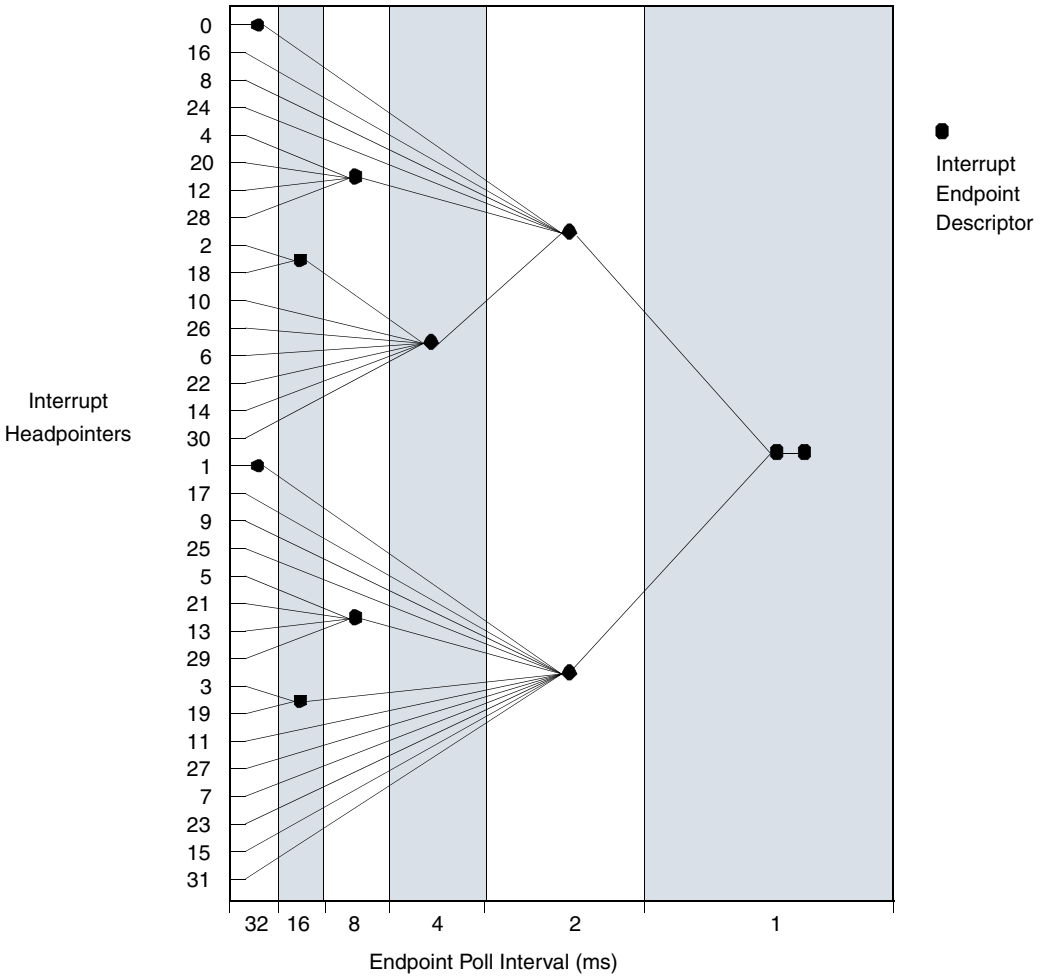



**Figure 12-5. Sample Interrupt Endpoint Schedule**

## 12.4 Host Control (HC) Operational Registers

Host Control contains a set of on-chip operational registers which are mapped into a non-cacheable portion of the system addressable space. These registers are used by the HCD. According to the function of these registers, they are divided into four partitions, specifically for control and status, memory pointer, frame counter and root hub. All of the registers should be read and written as 32-bit words.

Reserved bits may be allocated in future releases of this specification. To ensure interoperability, the HCD that does not use a reserved field should not assume the reserved field contains 0. In addition, HCD should always preserve the reserved field value(s).

When a R/$\overline{W}$ register is modified, the HCD should first read the register and modify the bits desired. Then, HCD should write the register with the reserved bits still containing the read value. Alternatively, HCD can maintain an in-memory copy of previously written values that can be modified and written to the HC register. When a write to the set/clear register is written, bits written to reserved fields should be 0.

### 12.4.1 Programming Note

Programmers should observe the following notes:

1. The CDM 48MHz Fractional Divider Configuration Register must be initialized before you can access any USB registers. If this register is not initialized, every USB register access will cause a machine check interrupt.

   For Example: If the SYS_XTAL_IN frequency is 33 MHz and the RST_CFG6 pin is low (multiplier 16), than the four phase divide ratios must be set to 0x5, fractional counter divide ration of $f_{system}/11$. 33 MHz * 16 / 11 = 48 MHz (USB frequency)
2. The GPS Port Configuration Register must be initialized to communicate over the muxed USB port. It configures USB for Differential or SE0 mode, the port to be used for USB2 and if the IrDA/USB 48 MHz clock is generated internally or externally.

### 12.4.2 Control and Status Partition

This HC partition uses 6 32-bit registers. These registers are located at an offset from MBAR of 0x1000. Register addresses are relative to this offset. Therefore, the actual register address is: **MBAR + 0x1000 + register address**

The following registers are available:

- USB HC Revision Register (0x1000)
- USB HC Control Register (0x1004)
- USB HC Command Status Register (0x1008)
- USB HC Interrupt Status Register (0x100C)
- USB HC Interrupt Enable Register (0x1010)
- USB HC Interrupt Disable Register (0x1014)

### 12.4.2.1 USB HC Revision Register

Address MBAR + 0x1000

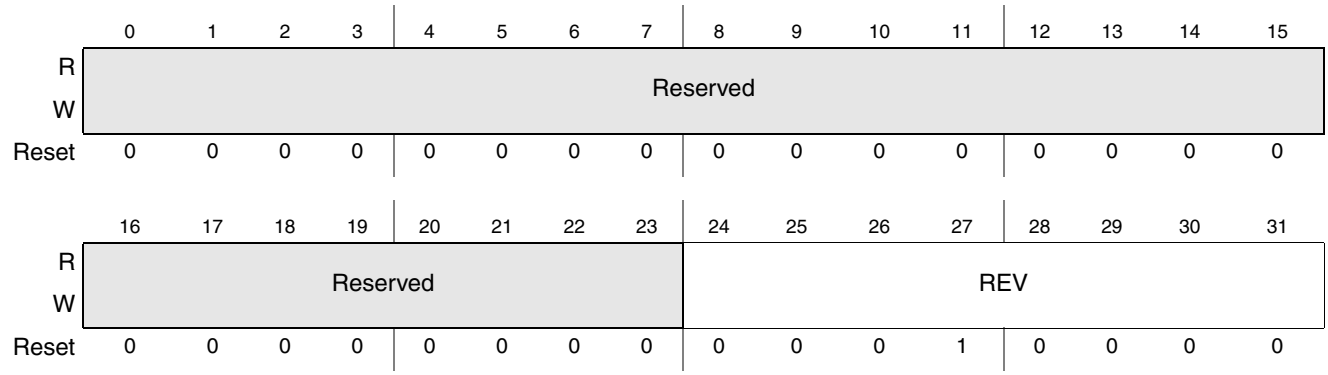



**Figure 12-6. USB HC Revision Register**

**Table 12-1. USB HC Revision Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:23 | – | Reserved |
| 24:31 | REV | Revision—a read-only field containing the BCD representation of the HCI specification version implemented by this HC. For example, a value of 11h corresponds to version 1.1. All HC implementations compliant with this specification have a value of 10h. |

### 12.4.2.2 USB HC Control Register

The HC Control register defines HC operating modes. Except for HostController FunctionalState and RemoteWakeUpConnected, most fields in this register are modified only by the HCD.

Address MBAR + 0x1004

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | RWE | RWC | IR | HCFS | | BLE | CLE | IE | PLE | CBSR | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-7. USB HC Control Register**

**Table 12-2. USB HC Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:20 | — | Reserved |
| 21 | RWE | RemoteWakeUpEnable—HCD uses bit to enable or disable the remote WakeUp feature on detection of upstream resume signaling.<br>When this bit is set and the ResumeDetected bit in HcInterruptStatus is set, a remote WakeUp is signaled to the host system. Setting this bit has no impact on the generation of hardware interrupt. |
| 22 | RWC | RemoteWakeUpConnected—bit indicates whether HC supports remote WakeUp signaling. If remote WakeUp is supported and used by the system it is the responsibility of system firmware to set this bit during BOOT UP.<br>HC clears bit on a hardware reset, but does not alter it on a software reset. Host system remote WakeUp signaling is host-bus-specific and not described in this specification. |
| 23 | IR | InterruptRouting—bit determines routing of interrupts generated by events registered in HcInterruptStatus.<br>The IR Bit is ignored by the MPC5200B. It is here to maintain OHCI compliancy. The interrupt from the USB module is routed to the interrupt controller in the SIU where it can be routed to the SMI or NORMAL interrupt. |
| 24:25 | HCFS | HostControllerFunctionalState—a USB field:<br>00 USBRESET<br>01 USBRESUME<br>10 USBOPERATIONAL<br>11 USBSUSPEND<br>Transition to USBOPERATIONAL from another state causes SOF generation to begin 1ms later. HCD may determine if HC has begun sending SOFs by reading the StartofFrame field of HcInterruptStatus. This field may be changed by HC, only when in the USBSUSPEND state. HC may move from the USBSUSPEND state to the USBRESUME state after detecting resume signaling from a downstream port. HC enters USBSUSPEND after a software reset, whereas it enters USBRESET after a hardware reset. A hardware reset also resets the Root Hub and asserts subsequent reset signaling to downstream ports. |

**Table 12-2. USB HC Control Register Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 26 | BLE | BulkListEnable—setting bit enables Bulk list processing in next Frame.<br>• If cleared by HCD, Bulk list processing does not occur after next SOF. HC checks this bit whenever it determines to process the list. When disabled, HCD may modify the list.<br>• If HcBulkCurrentED points to an ED to be removed, HCD advances pointer by updating HcBulkCurrentED before re-enabling list processing. |
| 27 | CLE | ControlListEnable—setting bit enables Control list processing in next Frame.<br>• If cleared by HCD, Control list processing does not occur after next SOF. HC checks this bit whenever it determines to process the list. When disabled, HCD may modify the list.<br>• If HcControlCurrentED points to an ED to be removed, HCD advances pointer by updating HcControlCurrentED before re-enabling list processing. |
| 28 | IE | IsochronousEnable—HCD uses bit to enable/disable isochronous EDs processing. While processing the periodic list in a Frame, HC checks bit status when it finds an Isochronous ED (F=1).<br>• If set (enabled), HC continues processing the EDs.<br>• If cleared (disabled), HC halts periodic list processing, which now contains only isochronous EDs, and begins processing Bulk/Control lists.<br>Setting this bit is guaranteed to take effect in the next Frame, not the current Frame. |
| 29 | PLE | PeriodicListEnable—setting bit enables periodic list processing in next Frame. If cleared by HCD, periodic list processing does not occur after the next SOF. HC checks this bit prior to starting list processing. |
| 30:31 | CBSR | ControlBulkServiceRatio—field specifies the service ratio between Control and Bulk EDs. Before processing non-periodic lists, HC compares the ratio specified with its internal count on how many non-empty Control EDs have been processed, in determining whether to continue serving another Control ED or switching to Bulk EDs. When crossing the frame boundary, the internal count is retained. In case of reset, HCD is responsible for restoring this value.<br>CBSR=Number of Control EDs Over Bulk EDs Served<br>0 1:1<br>1 2:1<br>2 3:1<br>3 4:1 |

### 12.4.2.3 USB HC Command Status Register

HC uses the HC Command Status register to receive (Rx) commands issued by HCD. It reflects the current HC status. To HCD, it appears to be a write-to-set register. HC ensures bits written as 1 are set in the register, while bits written as 0 remain unchanged in the register. HCD may issue multiple distinct commands to HC without concern for corrupting previously issued commands. HCD has normal read access to all bits.

The SchedulingOverrunCount field indicates the number of frames in which HC detects scheduling overrun errors. This occurs when the Periodic list does not complete before EOF. When a scheduling overrun error is detected, HC increments the counter and sets SchedulingOverrun field in HcInterruptStatus register.

Address MBAR + 0x1008

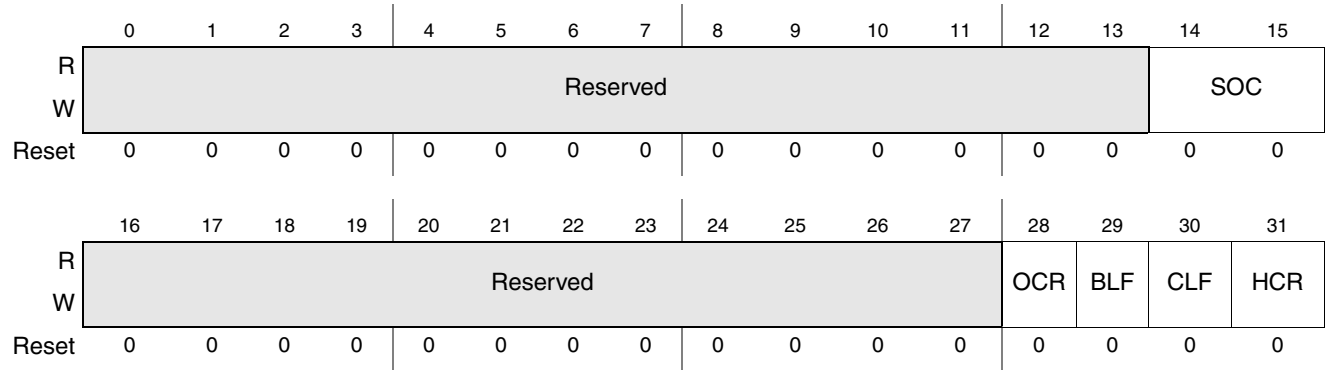



**Figure 12-8. USB HC Command Status Register**

**Table 12-3. USB HC Command Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:13 | — | Reserved |
| 14:15 | SOC | SchedulingOverrunCount—bits are incremented on each scheduling overrun error. SOC is initialized to 00 and wraps at 11. SOC increments when a scheduling overrun is detected, even if SchedulingOverrun in HcInterruptStatus has already been set. HCD uses SOC to monitor any persistent scheduling problems. |
| 16:27 | — | Reserved |
| 28 | OCR | OwnershipChangeRequest—OS HCD sets this bit to request an HC change of control. When set, HC sets the OwnershipChange field in HcInterruptStatus. After changeover, this bit is cleared and remains clear until the next OS HCD request. |
| 29 | BLF | BulkListFilled—bit indicates whether there are Bulk List TDs. HCD sets this bit when it adds a TD to a Bulk List ED. When HC begins processing the Bulk List head, it checks BF.<br>• If BLF is 0, HC does not start Bulk List processing.<br>• If BLF is 1, HC starts Bulk List processing and sets BF to 0.<br>• If HC finds a Bulk List TD, HC sets BLF to 1, causing Bulk List processing to continue.<br>• If HC does not find a Bulk List TD and HCD does not set BLF, then BLF remains 0 when HC completes processing and Bulk List processing stops. |
| 30 | CLF | ControlListFilled—bit indicates whether there are Control List TDs. HCD sets this bit when it adds a TD to a Control List ED. When HC begins processing the Control List head, it checks CLF.<br>• If CLF is 0, HC does not start Control List processing.<br>• If CF is 1, HC starts Control List processing and sets CLF to 0.<br>• If HC finds a Control List TD, CLF is set to 1, causing Control List processing to continue.<br>• If HC does not find a Control List TD and HCD does not set CLF, then CLF remains 0 when HC completes processing and Control List processing stops. |
| 31 | HCR | HostControllerReset—HCD sets bit to initiate a software reset of HC. Regardless of the HC functional state, it moves to the USBSUSPEND state in which most of the operational registers are reset except those stated otherwise. For example, HcControl Interrupt Routing field and no Host bus access is allowed.<br>On completion of the reset operation, HC clears this bit. Completion must be within 10ms. When set, this bit should not cause a root hub reset and no subsequent reset signaling should be asserted to downstream ports. |

### 12.4.2.4 USB HC Interrupt Status Register

This register provides status on various events that cause hardware interrupts. When an event occurs, HC sets the corresponding register bit. When a bit is set, a hardware interrupt is generated, if the interrupt is enabled in the HcInterruptEnable register and the MasterInterruptEnable bit is set. HCD may clear specific bits in this register by writing 1 to bit positions to be cleared. HCD may not set any of these bits. HC never clears the bit.

Address MBAR + 0x100C

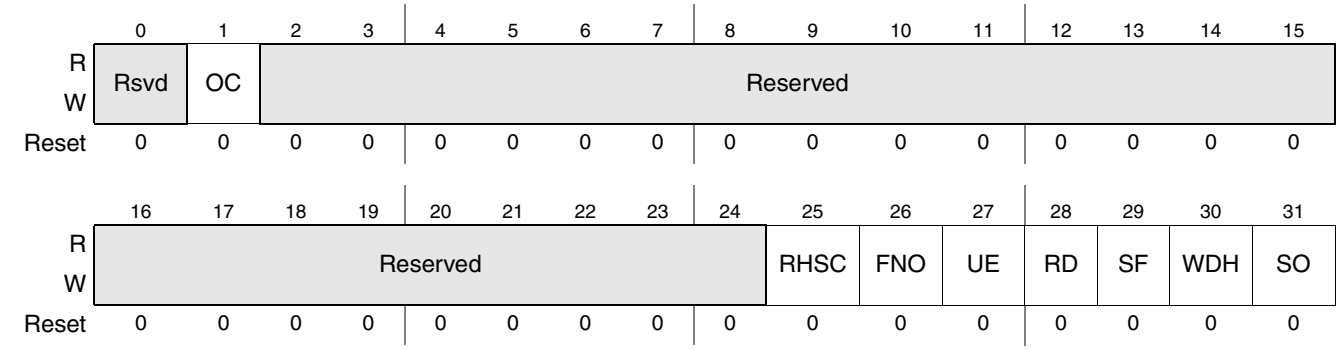



**Figure 12-9. USB HC Interrupt Status Register**

**Table 12-4. USB HC Interrupt Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | — | Reserved |
| 1 | OC | OwnershipChange—HC sets this bit when HCD sets the HcCommandStatus OwnershipChangeRequest field. This event, when unmasked, always generate an immediate System Management Interrupt (SMI).<br>When the SMI pin is not implemented, the OC bit is tied to 0. |
| 2:24 | — | Reserved |
| 25 | RHSC | RootHubStatusChange—bit is set when HcRhStatus content or content of any HcRhPortStatus[Number of Downstream Port] changes. |
| 26 | FNO | FrameNumberOverflow—bit is set when HcFmNumber msb (bit 15) changes value (from 0 to 1, or from 1 to 0) and after HccaFrameNumber is updated. |
| 27 | UE | UnrecoverableError—bit is set when HC detects a system error not related to USB. HC should not proceed with processing or signaling prior to the system error being corrected. HCD clears this bit after HC is reset. |
| 28 | RD | ResumeDetected—bit is set when HC detects a USB device asserting a resume signal. It is the transition from no resume signaling to resume signaling that causes this bit to be set. This bit is not set when HCD sets the USBRESUME state. |
| 29 | SF | StartofFrame—bit is set by HC at each start of a frame and after updating the HccaFrameNumber. HC also generates an SOF token at the same time. |
| 30 | WDH | WritebackDoneHead—bit is set immediately after HC writes HcDoneHead to HccaDoneHead. Further HccaDoneHead updates do not occur until this bit is cleared. HCD should only clear this bit after saving HccaDoneHead contents. |
| 31 | SO | SchedulingOverrun—bit is set when USB schedule for the current Frame overruns and after an HccaFrameNumber update. A scheduling overrun also causes the HcCommandStatus SOC to increment. |

### 12.4.2.5 USB HC Interrupt Enable Register

Each enable bit in the HC Interrupt Enable register corresponds to an associated interrupt bit in the HcInterruptStatus register. The HcInterruptEnable register is used to control which events generate a hardware interrupt. When:

1. Abit is set in the HcInterruptStatus register, and
2. The corresponding bit is set in the HcInterruptEnable register, and
3. The MasterInterruptEnable bit is set, then
4. Ahardware interrupt is requested on the host bus.

Writing 1 to a bit in this register sets the corresponding bit, whereas writing 0 to a bit in this register leaves the corresponding bit unchanged. On read, the current value of this register is returned.

Address MBAR + 0x1010

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | MIE | OC | Reserved | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | RHSC | FNO | UE | RD | SF | WDH | SO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-10. USB HC Interrupt Enable Register**

**Table 12-5. USB HC Interrupt Enable Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | MIE | Master Interrupt Enable—used by HCD.<br>0 Writing to this bit is ignored by HC.<br>1 Writing to this bit enables interrupt generation, due to events specified in other bits of this register. |
| 1 | OC | Ownership Change<br>0 Writing to this bit is ignored by HC.<br>1 Writing to this bit enables interrupt generation, due to ownership. |
| 2:24 | — | Reserved |
| 25 | RHSC | Root Hub Status Change<br>0 Ignore<br>1 Enable interrupt generation due to root hub status change. |
| 26 | FNO | Frame Number Overflow<br>0 Ignore<br>1 Enable interrupt generation due to frame number overflow. |
| 27 | UE | Unrecoverable Error<br>0 Ignore<br>1 Enable interrupt generation due to unrecoverable error. |
| 28 | RD | Resume Detected<br>0 Ignore<br>1 Enable interrupt generation due to resume detect. |

**Table 12-5. USB HC Interrupt Enable Register Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 29 | SF | StartofFrame<br>0 Ignore<br>1 Enable interrupt generation due to start of frame. |
| 30 | WDH | WritebackDoneHead<br>0 Ignore<br>1 Enable interrupt generation due to HcDoneHead writeback. |
| 31 | SO | SchedulingOverrun<br>0 Ignore<br>1 Enable interrupt generation due to scheduling overrun. |

## 12.4.2.6 USB HC Interrupt Disable Register

Each disable bit in the HC Interrupt Disable register corresponds to an associated interrupt bit in the HcInterruptStatus register. The HcInterruptDisable register is coupled with the HcInterruptEnable register. Thus, writing a ‘1’ to a bit in this register clears the corresponding bit in the HcInterruptEnable register, whereas writing a ‘0’ to a bit in this register leaves the corresponding bit in the HcInterruptEnable register unchanged. On read, the current value of the HcInterruptEnable register is returned.

Address MBAR + 0x1014

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | MIE | OC | Reserved | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | RHSC | FNO | UE | RD | SF | WDH | SO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-11. USB HC Interrupt Disable Register**

**Table 12-6. USB HC Interrupt Disable Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | MIE | Master Interrupt Enable—bit is set after a hardware or software reset.<br>0 Written to this bit is ignored by HC.<br>1 Written to this bit disables interrupt generation, due to events specified in other bits of this register. |
| 1 | OC | OwnershipChange<br>0 Ignore<br>1 Disable interrupt generation due to Ownership Change |
| 2:24 | — | Reserved |
| 25 | RHSC | RootHubStatusChange<br>0 Ignore<br>1 Disable interrupt generation due to root hub status change. |
| 26 | FNO | FrameNumberOverflow<br>0 Ignore<br>1 Disable interrupt generation due to frame number overflow. |

**Table 12-6. USB HC Interrupt Disable Register Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 27 | UE | Unrecoverable Error<br>0 Ignore<br>1 Disable interrupt generation due to unrecoverable error. |
| 28 | RD | Resume Detected<br>0 Ignore<br>1 Disable interrupt generation due to resume detect. |
| 29 | SF | Start of Frame<br>0 Ignore<br>1 Disable interrupt generation due to start of frame. |
| 30 | WDH | Writeback Done Head<br>0 Ignore<br>1 Disable interrupt generation due to Hc Done Head writeback. |
| 31 | SO | Scheduling Overrun<br>0 Ignore<br>1 Disable interrupt generation due to scheduling overrun. |

### 12.4.3 Memory Pointer Partition

This HC partition uses 7 32-bit registers. These registers are located at an offset from MBAR of 0x1018. Register addresses are relative to this offset. Therefore, the actual register address is: **MBAR + 0x1018 + register address**

The following registers are available:

- USB HC HCCA Register (0x1018)
- USB HC Period Current Endpoint Descriptor Register (0x101C)
- USB HC Control Head Endpoint Descriptor Register (0x1020)
- USB HC Control Current Endpoint Descriptor Register (0x1024)
- USB HC Bulk Head Endpoint Descriptor Register (0x1028)
- USB HC Bulk Current Endpoint Descriptor Register (0x102C)
- USB HC Done Head Register (0x1030)

#### 12.4.3.1 USB HC HCCA Register

The HC HCCA register contains the physical address of the Host Controller Communication Area. HCD determines alignment restrictions by writing all 1s to HcHCCA and reading the HcHCCA content. Alignment is evaluated by examining the number of 0s in the lower order bits. Minimum alignment is 256Bytes. Bits 0 through 7 must always return 0 when read. This area holds control structures and the interrupt table, which are accessed by both the HC and HCD.

Address MBAR + 0x1018

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | HCCA | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | HCCA | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-12. USB HC HCCA Register**

**Table 12-7. USB HC HCCA Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:23 | HCCA | Host Controller Communication Area—base address. |
| 24:31 | — | Reserved |

### 12.4.3.2 USB HC Period Current Endpoint Descriptor Register

The HC Period Current Endpoint Descriptor (ED) register contains the physical address of the current isochronous or interrupt endpoint descriptor.

Address MBAR + 0x101C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | PCED | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | PCED | | | | | | | | | | | | Reserved | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-13. USB HC Period Current Endpoint Descriptor Register**

**Table 12-8. USB HC Period Current Endpoint Descriptor Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:27 | PCED | PeriodCurrentED—HC uses this field to point to the head of one of the Periodic lists, which is processed in the current Frame. HC updates register content after a periodic ED is processed. HCD may read the content in determining which ED is currently being processed at the time of reading. |
| 28:31 | — | Reserved |

### 12.4.3.3 USB HC Control Head Endpoint Descriptor Register

The HC Control Head Endpoint Descriptor register contains the physical address of the first endpoint descriptor of the Control list.

Address MBAR + 0x1020

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | CHED | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | CHED | | | | | | | | | | | | Reserved | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-14. USB HC Control Head Endpoint Descriptor Register**

**Table 12-9. USB HC Control Head Endpoint Descriptor Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:27 | CHED | ControlHeadED—HC traverses the control list starting with the HcControlHeadED pointer. Content is loaded from HCCA during HC initialization. |
| 28:31 | — | Reserved |

### 12.4.3.4 USB HC Control Current Endpoint Descriptor Register

The HC Control Current Endpoint Descriptor register contains the physical address of the current control list endpoint descriptor.

Address MBAR + 0x1024

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | CCED | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | CCED | | | | | | | | | | | | Reserved | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-15. USB HC Control Current Endpoint Descriptor Register**

**Table 12-10. USB HC Control Current Endpoint Descriptor Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:27 | CCED | ControlCurrentED—pointer is advanced to next ED after serving the present one. HC continues processing the list from where it left off in the last frame. When it reaches the control list end, HC checks the HcCommandStatus ControlListFilled.<br>• If set, CCED copies HcControlHeadED content to HcControlCurrentED and clears bit.<br>• If not set, it does nothing.<br>HCD is allowed to modify this register only when the ControlListEnable of HcControl is cleared. When set, HCD only reads the instantaneous value of this register. Initially, this is set to 0 to indicate the end of the Control List. |
| 28:31 | — | Reserved |

### 12.4.3.5 USB HC Bulk Head Endpoint Descriptor Register

The HC Head Endpoint Descriptor register contains the physical address of the first bulk list endpoint descriptor.

Address MBAR + 0x1028

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | BHED | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | BHED | | | | | | | | | | | | Reserved | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-16. USB HC Bulk Head Endpoint Descriptor Register**

**Table 12-11. USB HC Bulk Head Endpoint Descriptor Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:27 | BHED | BulkHeadED—HC traverses the Bulk List starting with the HcBulkHeadED pointer. The content is loaded from HCCA during the HC initialization. |
| 28:31 | — | Reserved |

### 12.4.3.6 USB HC Bulk Current Endpoint Descriptor Register

The HC Bulk Current Endpoint Descriptor register contains the physical address of the current endpoint of the bulk list. The bulk list is served in a round-robin fashion, therefore endpoints are ordered according to their insertion into the list.

Address MBAR + 0x102C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | BCED | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | BCED | | | | | | | | | | | | Reserved | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-17. USB HC Bulk Current Endpoint Descriptor Register**

**Table 12-12. USB HC Bulk Current Endpoint Descriptor Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:27 | BHED | BulkCurrentED—advances to the next ED after HC has served the present ED.<br>HC continues processing the list from where it left off in the last Frame. When it reaches the end of the Bulk List, HC checks the HcCommandStatus BulkListFilled.<br>• If set, BHED copies HcBulkHeadED content to HcBulkCurrentED and clears bit.<br>• If not set, it does nothing.<br>HCD is only allowed to modify this register when HcControl BulkListEnable is cleared. When set, HCD only reads the instantaneous value of this register. This is initially set to 0 to indicate the end of the Bulk List. |
| 28:31 | — | Reserved |

### 12.4.3.7 USB HC Done Head Register

The HC Done Head register contains the physical address of the last completed transfer descriptor that was added to the done queue. In normal operation, HCD does not need to read this register as its content is periodically written to the HCCA.

Address MBAR + 0x1030

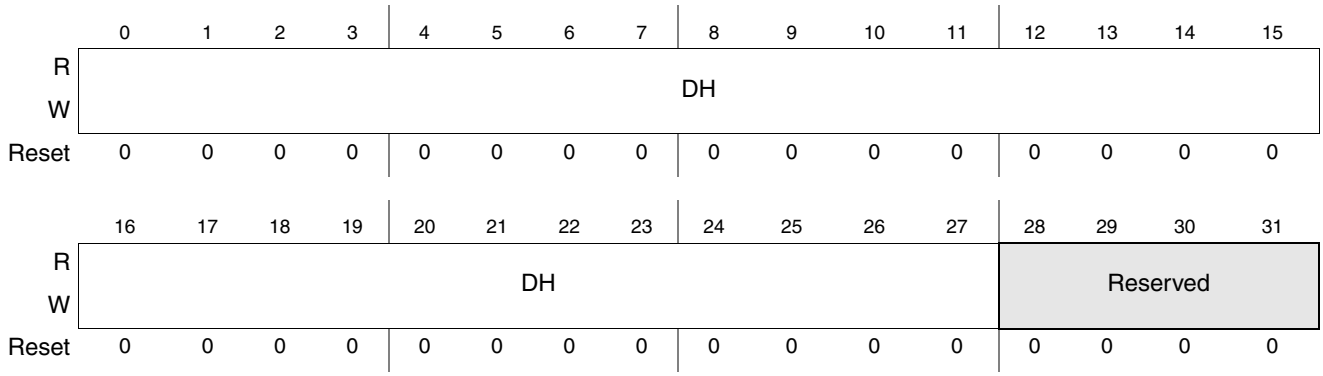



**Figure 12-18. USB HC Done Head Register**

**Table 12-13. USB HC Done Head Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:27 | DH | DoneHead—When a TD is complete, HC writes the HcDoneHead content to the TD NextTD field. HC then overwrites the HcDoneHead content with the TD address. This is set to 0 when HC writes the register content to HCCA. HcInterruptStatus WritebackDoneHead is also set. |
| 28:31 | — | Reserved |

## 12.4.4 Frame Counter Partition

This HC partition uses 5 32-bit registers. These registers are located at an offset from MBAR of 0x1034. Register addresses are relative to this offset. Therefore, the actual register address is: **MBAR + 0x1034 + register address**

The following registers are available:

- USB HC Frame Interval Register Field Descriptions (0x1034)
- USB HC Frame Remaining Register (0x1038)
- USB HC Frame Number Register (0x103C)
- USB HC Periodic Start Register (0x1040)
- USB HC LS Threshold Register (0x1044)

### 12.4.4.1 USB HC Frame Interval Register

The HC Frame Interval register contains a 14-bit value that indicates:

- The bit-time interval in a Frame. For example, between two consecutive SOFs.
- A 15-bit value that indicates the full speed maximum packet size the HC may transmit or receive without causing scheduling overruns.

HCD may carry out minor adjustment on the frame interval by writing a new value over the present one at each SOF. This provides the programmability necessary for the HC to synchronize with an external clocking resource and to adjust any unknown local clock offset.

Address MBAR + 0x1034

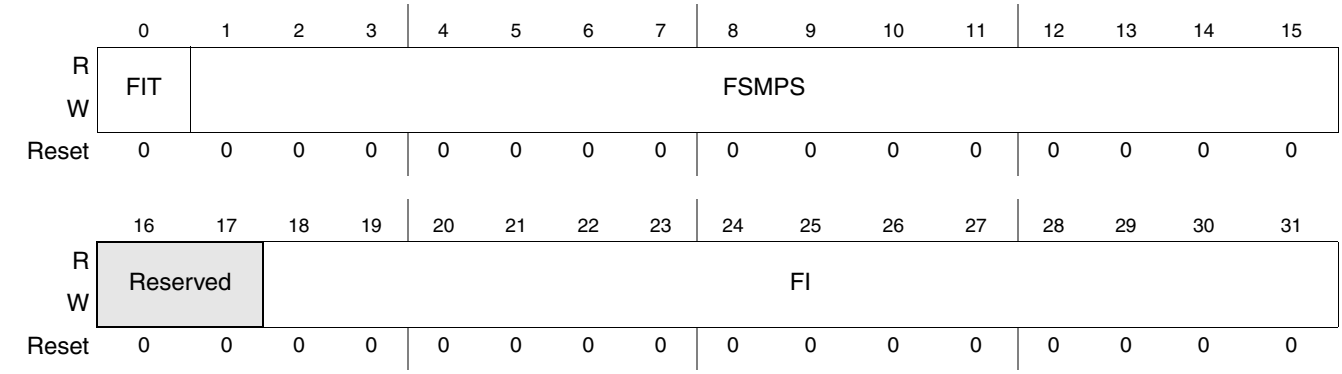



**Figure 12-19. USB HC Frame Interval Register**

**Table 12-14. USB HC Frame Interval Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | FIT | Frame Interval Toggle—HCD toggles this bit when it loads a new value to the frame interval. |
| 1:15 | FSMPS | FS Largest Data Packet—specifies a value that is loaded into the largest data packet counter at the beginning of each frame. The counter value represents the largest amount of data in bits that the HC can send or received in a single transaction at any given time without causing scheduling overrun. HCD calculates this field value. |
| 16:17 | — | Reserved |
| 18:31 | FI | Frame Interval—specifies the bit-time interval between two consecutive SOFs. Nominally, this value is set to 11,999. HCD should store the field's current value before resetting HC. Setting the Hc Command Status Host Controller Reset field causes the HC to reset this field to its nominal value. HCD may choose to restore the stored value when the reset sequence completes. |

### 12.4.4.2 USB HC Frame Remaining Register

This register is a 14-bit count-down counter containing the remaining current Frame bit-time.

Address MBAR + 0x1038

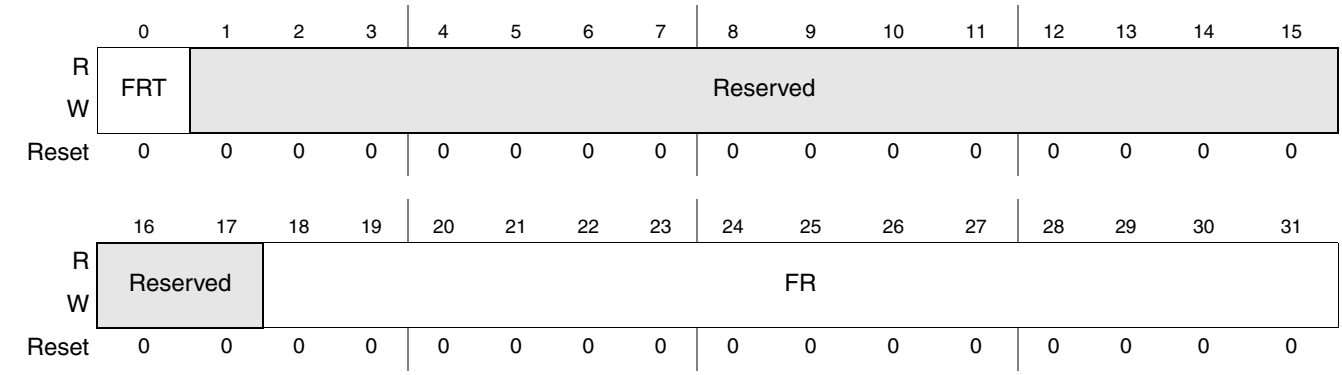



**Figure 12-20. USB HC Frame Remaining Register**

**Table 12-15. USB HC Frame Remaining Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | FRT | FrameRemainingToggle—bit is loaded from the HcFmInterval FrameIntervalToggle field when FrameRemaining reaches 0. HCD uses this bit for synchronization between FrameInterval and FrameRemaining. |
| 1:17 | — | Reserved |
| 18:31 | FR | FrameRemaining—is a counter that is decremented at each bit-time. When it reaches 0, it is reset by loading the FrameInterval value specified in HcFmInterval at the next bit-time boundary.<br>When entering the USBOPERATIONAL state, HC reloads the content with the HcFmInterval FrameInterval and uses the updated value from the next SOF. |

### 12.4.4.3 USB HC Frame Number Register

The HC Frame Number register is a 16-bit counter. It provides a timing reference among events happening in the HC and HCD. The HC driver may use the 16-bit value specified in this register and generate a 32-bit frame number without requiring frequent access to the register.

Address MBAR + 0x103C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | FN | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-21. USB HC Frame Number Register**

**Table 12-16. USB HC Frame Number Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 16:31 | FN | FrameNumber—is incremented when HcFmRemaining is re-loaded. FN rolls over to 0 after ffff. When entering the USBOPERATIONAL state, this is automatically incremented. Content is written to HCCA after HC has incremented the FN at each frame boundary and sent a SOF, but before HC reads the first ED in that frame. After writing to HCCA, HC sets the HcInterruptStatus StartofFrame. |
| 0:15 | — | Reserved |

### 12.4.4.4 USB HC Periodic Start Register

This register has a 14-bit programmable value that determines when is the earliest time HC should start processing the periodic list.

Address MBAR + 0x1040

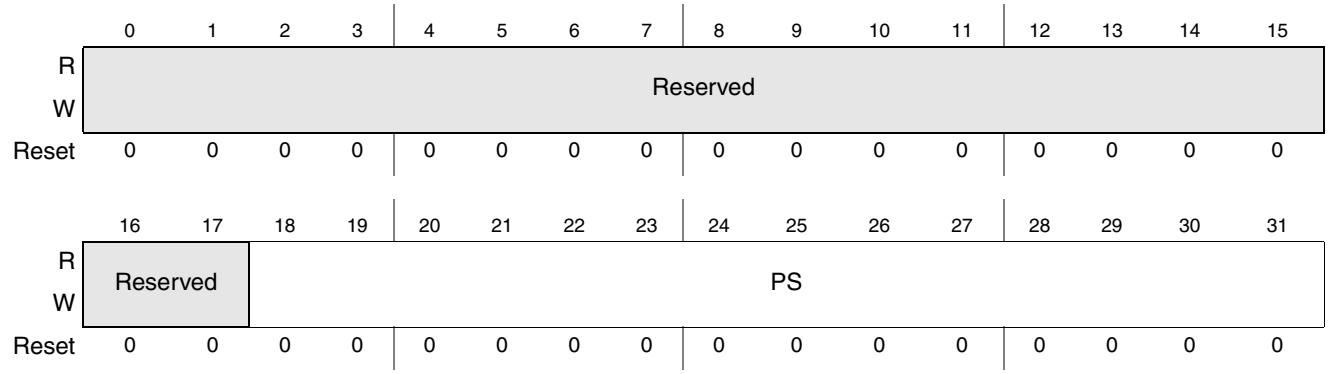



**Figure 12-22. USB HC Periodic Start Register**

**Table 12-17. USB HC Periodic Start Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:17 | — | Reserved |
| 18:31 | PS | PeriodicStart—field is cleared after a hardware reset. PS is then set by HCD during HC initialization. PS value is calculated roughly as 10% off from HcFmInterval. A typical value is 3E67.<br>When HcFmRemaining reaches the value specified, processing of periodic lists has priority over Control/Bulk processing. HC then starts processing the Interrupt list after completing the current Control or Bulk transaction in progress. |

### 12.4.4.5 USB HC LS Threshold Register

This register contains an 11-bit value used by the HC to determine whether to commit to the transfer of a maximum 8-Byte LS packet before EOF. Neither the HC nor HCD are allowed to change this value.

Address MBAR + 0x1044

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | LST | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-23. USB HC LS Threshold Register**

**Table 12-18. USB HC LS Threshold Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:19 | — | Reserved |
| 20:31 | LST | LSThreshold—field contains a value which is compared to the FrameRemaining field prior to initiating a low speed transaction. The transaction is started only if FrameRemaining is greater than or equal to this field. HCD calculates this value with the consideration of transmission and setup overhead. |

### 12.4.5 Root Hub Partition

This HC partition uses 5 32-bit registers. These registers are located at an offset from MBAR of 0x1048. Register addresses are relative to this offset. Therefore, the actual register address is: **MBAR + 0x1048 + register address**

The following registers are available:

- USB HC Rh Descriptor A Register (0x1048)
- USB HC Rh Descriptor B Register Field Descriptions (0x104C)
- USB HC Rh Status Register Field Descriptions (0x1050)
- USB HC Rh Port1 Status Register (0x1054)
- USB HC Rh Port2 Status Register (0x1058)

All registers included in this partition are dedicated to the USB root hub, which is an integral part of the HC though still a functionally separate entity. HCD emulates USBD access to the root hub via a register interface. HCD maintains many USB-defined hub features which are not required to be supported in hardware. For example, the hub's device, configuration, interface, and endpoint descriptors are maintained only in the HCD and some class descriptor static fields. HCD also maintains and decodes the root hub device address as well as other trivial operations better suited to software than hardware.

The root hub register interface is otherwise developed to maintain similarity of bit organization and operation to typical hubs which are found in the system. Each register is read and written as a 32-bit word. These registers are only written during initialization to correspond with the system implementation.

- HcRhDescriptorA and HcRhDescriptorB registers should be implemented such that they are writeable regardless of the HC USB state.
- HcRhStatus and HcRhPortStatus must be writeable during the USBOPERATIONAL state.

**NOTE**

IS denotes an implementation-specific reset value for that field.

#### 12.4.5.1 USB HC Rh Descriptor A Register

This register is the first of two registers describing the root hub characteristics. Reset values are implementation-specific. The HCD emulates the following hub class descriptor fields:

- Descriptor length (11)
- Descriptor type (TBD)
- Hub controller current (0)

All other fields are located in the HcRhDescriptorA and HcRhDescriptorB registers.

Address MBAR + 0x1048

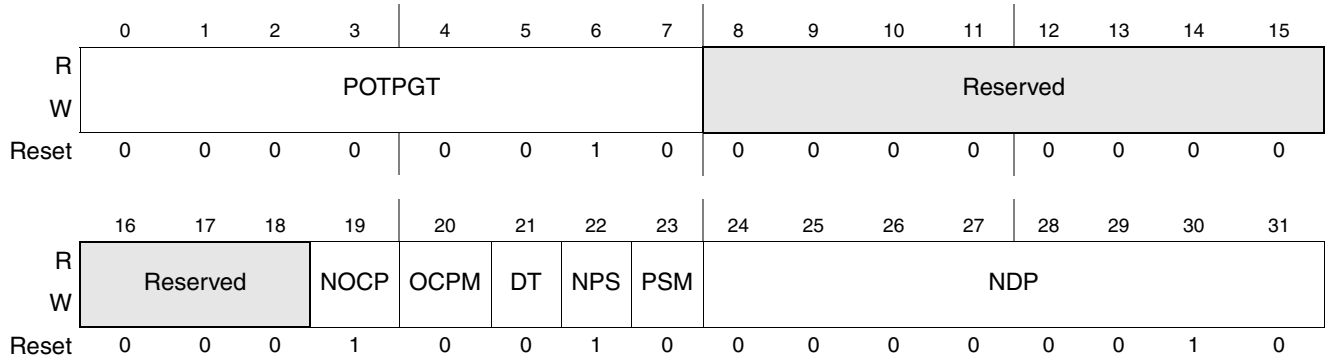



**Figure 12-24. USB HC Rh Descriptor A Register**

**Table 12-19. USB HC Rh Descriptor A Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:7 | POTPGT | PowerOnToPowerGoodTime—specifies the duration HCD must wait before accessing a Root Hub powered-on port. POTPGT is implementation-specific.<br>The time unit is 2ms. Duration is calculated as POTPGT x 2ms. |
| 8:18 | — | Reserved |
| 19 | NOCP | NoOverCurrentProtection—describes how the Root Hub port overcurrent status is reported. When NOCP is cleared, OCPM specifies global or per-port reporting.<br>0 Overcurrent status is reported collectively for all downstream ports.<br>1 No overcurrent protection supported. |
| 20 | OCPM | OverCurrentProtectionMode—describes how the Root Hub port overcurrent status is reported. At reset, OCPM should reflect the same mode as PowerSwitchingMode. OCPM is valid only if NoOverCurrentProtection is cleared.<br>0 Overcurrent status is reported collectively for all downstream ports.<br>1 Overcurrent status is reported on a per-port basis. |
| 21 | DT | DeviceType—specifies Root Hub is not a compound device. Root Hub is not permitted to be a compound device. DT should always read/write 0. |
| 22 | NPS | NoPowerSwitching—specifies whether power switching is supported or ports are always powered. NPS is implementation specific. When this bit is cleared, PSM specifies global or per-port switching.<br>0 Ports are power switched.<br>1 Ports are always powered on when HC is powered on. |
| 23 | PSM | PowerSwitchingMode—specifies how the root hub port power switching is controlled. PSM is implementation-specific and is only valid if the NoPowerSwitching field is cleared.<br>0 All ports are powered at the same time.<br>1 Each port is powered individually. This mode lets port power be controlled by either the global switch or per-port switching.<br>• If PortPowerControlMask bit is set, port responds only to port power commands (Set/ClearPortPower).<br>• If port mask is cleared, port is controlled only by the global power switch (Set/ClearGlobalPower). |
| 24:31 | NDP | NumberDownstreamPorts—specifies the number of downstream ports supported by the Root Hub. NDP is implementation-specific.<br>• Minimum number of ports is 1.<br>• Maximum number of ports (supported by OpenHCI) is 15. |

### 12.4.5.2 USB HC Rh Descriptor B Register

This register is the second of two registers describing the Root Hub characteristics. These fields are written during initialization to correspond with the system implementation. Reset values are implementation-specific.

Address MBAR + 0x104C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | PPCM | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | DR | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-25. USB HC Rh Descriptor B Register**

**Table 12-20. USB HC Rh Descriptor B Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:15 | PPCM | PortPowerControlMask—each bit indicates whether a port is affected by a global power control command when PSM is set.<br>• When set, port power state is only affected by per-port power control (Set/ClearPortPower).<br>• When cleared, port is controlled by the global power switch (Set/ClearGlobalPower).<br>If device is configured to Global Switching Mode (PSM=0), this field is not valid.<br>bit 0—Reserved<br>bit 1—Ganged-power mask on Port #1<br>bit 2—Ganged-power mask on Port #2<br>…<br>bit15—Ganged-power mask on Port #15 |
| 16:31 | DR | NDeviceRemovable—each bit is dedicated to a Root Hub port. When cleared, the attached device is removable. When set, the attached device is not removable.<br>bit 0—Reserved<br>bit 1—Device attached to Port #1<br>bit 2—Device attached to Port #2<br>…<br>bit15—Device attached to Port #15 |

### 12.4.5.3 USB HC Rh Status Register

This register is divided into two parts. The lower 16 bits of a 32-bit word represents the hub status field; the upper word represents the hub status change field. Reserved bits should always be written 0.

Address MBAR + 0x1050

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | CRWE | Reserved | | | | | | | | | | | | | OCIC | LPSC |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | DRWE | Reserved | | | | | | | | | | | | | OCI | LPS |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-26. USB HC Rh Status Register**

**Table 12-21. USB HC Rh Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | CRWE | ClearRemoteWakeUpEnable (write)<br>• Writing 1 clears DRWE.<br>• Writing 0 has no effect. |
| 1:13 | — | Reserved |
| 14 | OCIC | OverCurrentIndicatorChange—is set by hardware when a change occurs to the OCI field of this register.<br>• Writing 1 causes HCD to clear this bit.<br>• Writing 0 has no effect. |
| 15 | LPSC | LocalPowerStatusChange (read)—Root Hub does not support the local power status feature. Thus, this bit is always read as 0.<br>SetGlobalPower (write)<br>• In global power mode (PSM=0), LPSC is written to 1 to turn on power to all ports (clear PortPowerStatus).<br>• In per-port power mode, LPSC sets PortPowerStatus only on ports whose PPCM bit is not set.<br>Writing 0 has no effect. |
| 16 | DRWE | DeviceRemoteWakeUpEnable (write)—enables a ConnectStatusChange bit as a resume event, causing a USBSUSPEND to USBRESUME state transition and setting the ResumeDetected interrupt.<br>0 ConnectStatusChange is not a remote WakeUp event.<br>1 ConnectStatusChange is a remote WakeUp event.<br>SetRemoteWakeUpEnable (read).<br>1 Sets DRWE.<br>0 Has no effect. |
| 17:29 | — | Reserved |

**Table 12-21. USB HC Rh Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 30 | OCI | OverCurrentIndicator—reports overcurrent conditions when global reporting is implemented.<br>When set, an overcurrent condition exists.<br>When cleared, all power operations are normal.<br>If per-port overcurrent protection is implemented this bit is always 0. |
| 31 | LPS | LocalPowerStatus—Root Hub does not support the local power status feature. This bit is always read as 0 (write) ClearGlobalPower.<br>In global power mode (PSM=0), bit is written to 1 to turn off power to all ports (clear PortPowerStatus).<br>In per-port power mode, bit clears PortPowerStatus only on ports whose PPCM bit is not set.<br>Writing 0 has no effect. |

## 12.4.5.4 USB HC Rh Port1 Status Register

This register is controls and reports port events on a per-port basis. The Number of Downstream Ports (NDP) represents the number of HcRhPortStatus registers that are implemented in hardware. The lower 16-bits is used to reflect the port status; the upper 16-bits reflects the status change bits. MPC5200B has NDP = 2, therefore, HcRhPort1Status (MBAR + 1054) and HcRhPort2Status (MBAR + 1058).

Some status bits are implemented with special write behavior. If a transaction (token through handshake) is in progress when a write to change port status occurs, the resulting port status change is postponed until the transaction completes. Reserved bits should always be written 0.

Address MBAR + 0x1054

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | PRSC | OCIC | PSSC | PESC | CSC |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | LSDA | PPS | Reserved | | | PRS | POCI | PSS | PES | CCS |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-27. USB HC Rh Port1 Status Register**

**Table 12-22. USB HC Rh Port1 Status Register Field Descriptions (Sheet 1 of 4)**

| Bits | Name | Description |
|---|---|---|
| 0:10 | — | Reserved |
| 11 | PRSC | PortResetStatusChange—bit is set at the end of the 10ms port reset signal.<br>• Writing 1 causes HC to clear this bit.<br>• Writing 0 has no effect.<br>0 Port reset not complete<br>1 Port reset complete |

**Table 12-22. USB HC Rh Port1 Status Register Field Descriptions (Sheet 2 of 4)**

| Bits | Name | Description |
|---|---|---|
| 12 | OCIC | PortOverCurrentIndicatorChange—bit is valid only if overcurrent conditions are reported on a per-port basis. This bit is set when Root Hub changes the PortOverCurrentIndicator bit.<br>• Writing 1 causes HC to clear this bit.<br>• Writing 0 has no effect.<br>0 No change in POCI<br>1 POCI has changed |
| 13 | PSSC | PortSuspendStatusChange—bit is set when the full resume sequence completes. Sequence includes a 20s resume pulse, LS EOP, and 3ms resychronization delay.<br>• Writing 1 causes HC to clear this bit.<br>• Writing 0 has no effect.<br>This bit is also cleared when ResetStatusChange is set.<br>0 Resume not complete<br>1 Resume complete |
| 14 | PESC | PortEnableStatusChange—bit is set when hardware events cause the PES bit to be cleared. Changes from HCD writes do not set this bit.<br>• Writing 1 causes HC to clear this bit.<br>• Writing 0 has no effect.<br>0 No change in PES<br>1 Change in PES |
| 15 | CSC | ConnectStatusChange—bit is set whenever a connect or disconnect event occurs.<br>• Writing 1 causes HC to clear this bit.<br>• Writing 0 has no effect.<br>If CCS is cleared when a SetPortReset, SetPortEnable, or SetPortSuspend write occurs, this bit is set to force the driver to re-evaluate the connection status since these writes should not occur if the port is disconnected.<br>0 No change in CCS<br>1 Change in CCS<br>If the DeviceRemovable[NDP] bit is set, this bit is set only after a Root Hub reset to notify the system that the device is attached. |
| 16:21 | — | Reserved |
| 22 | LSDA | LowSpeedDeviceAttached (read)—bit indicates the speed of the device attached to this port.<br>0 Full speed device attached<br>1 Low speed device attached<br>This field is valid only when CurrentConnectStatus is set.<br>ClearPortPower (write)<br>• Writing 1 causes HC to clear the PortPowerStatus bit.<br>• Writing 0 has no effect. |

**Table 12-22. USB HC Rh Port1 Status Register Field Descriptions (Sheet 3 of 4)**

| Bits | Name | Description |
|---|---|---|
| 23 | PPS | PortPowerStatus (read)—bit reflects the port power status, regardless of the type of power switching implemented.<br>If an overcurrent condition is detected, this bit is cleared. HCD sets this bit by writing SetPortPower or SetGlobalPower. HCD clears this bit by writing ClearPortPower or ClearGlobalPower. Which power control switches are enabled is determined by PowerSwitchingMode and PortPortControlMask[NDP].<br>In global switching mode (PSM=0), only Set/ClearGlobalPower controls this bit.<br>In per-port power switching (PSM=1), if the PortPowerControlMask[NDP] bit for the port is set, only Set/ClearPortPower commands are enabled.<br>If the mask is not set, only Set/ClearGlobalPower commands are enabled.<br>If port power is disabled, CurrentConnectStatus, PortEnableStatus, PortSuspendStatus, and PortResetStatus should be reset.<br>0 Port power is off<br>1 Port power is on<br>SetPortPower (write)<br>• Writing causes HC to set the PortPowerStatus bit.<br>• Writing 0 has no effect.<br>If power switching is not supported, this bit always reads ‘1b’. |
| 24:26 | — | Reserved |
| 27 | PRS | PortResetStatus (read)—When this bit is set by a write to SetPortReset, port reset signaling is asserted. When reset is completed, this bit is cleared when PortResetStatusChange is set. This bit cannot be set if CurrentConnectStatus is cleared.<br>0 Port reset signal is not active<br>1 Port reset signal is active<br>SetPortReset (write)<br>• Writing 1 causes HC to set port reset signaling.<br>• Writing 0 has no effect.<br>If CurrentConnectStatus is cleared, a write does not set PortResetStatus. Instead, it sets ConnectStatusChange. This notifies the driver that an attempt was made to reset a disconnected port. |
| 28 | POCI | PortOverCurrentIndicator (read)—bit is only valid when root hub is configured in such a way that overcurrent conditions are reported on a per-port basis.<br>If per-port overcurrent reporting is not supported, this bit is set to 0.<br>If cleared, all power operations are normal for this port.<br>If set, an overcurrent condition exists on this port. This bit always reflects the overcurrent input signal<br>0 No overcurrent condition.<br>1 Overcurrent condition detected.<br>ClearSuspendStatus (write)<br>• Writing 1 causes HC to initiate a resume.<br>• Writing 0 has no effect.<br>A resume is initiated only if PSS is set. |

**Table 12-22. USB HC Rh Port1 Status Register Field Descriptions (Sheet 4 of 4)**

| Bits | Name | Description |
|---|---|---|
| 29 | PSS | PortSuspendStatus (read)—bit indicates port is suspended or in resume sequence. It is set by a SetSuspendState write and cleared when PortSuspendStatusChange is set at the end of the resume interval.<br>This bit cannot be set if CCS. This bit is cleared when:<br>• PortResetStatusChange is set at the end of the port reset, or<br>• when HC is placed in the USBRESUME state.<br>If an upstream resume is in progress, it should propagate to the HC.<br>0 Port is not suspended<br>1 Port is suspended<br>SetPortSuspend (write)<br>• Writing 1 causes HC to set PSS bit.<br>• Writing 0 has no effect.<br>If CurrentConnectStatus is cleared, this write does not set PSS. Instead it sets ConnectStatusChange. This notifies the driver an attempt was made to suspend a disconnected port. |
| 30 | PES | PortEnableStatus (read)—indicates whether the port is enabled or disabled.<br>The Root Hub may clear this bit when the following conditions are detected:<br>• An overcurrent condition<br>• Disconnect event<br>• Switched-off power<br>• Operational bus error (such as babble)<br>This change causes PESC to be set. HCD sets this bit by writing SetPortEnable and clears it by writing ClearPortEnable.<br>PES cannot be set when CurrentConnectStatus is cleared. If not already set, PES is set at the completion of a port reset when ResetStatusChange is set or port suspend when SuspendStatusChange is set.<br>0 Port is disabled<br>1 Port is enabled<br>SetPortEnable (write)—HCD sets PES by writing 1. Writing 0 has no effect.<br>If CCS is cleared, this write does not set PES, but instead sets CSC. This notifies the driver that an attempt was made to enable a disconnected port. |
| 31 | CCS | CurrentConnectStatus (read)—reflects current state of downstream port.<br>0 No device connected<br>1 Device connected<br>ClearPortEnable (write)—HCD writes 1 to this bit to clear PortEnableStatus bit. Writing 0 has no effect. CCS is not affected by any write.<br>**Note:** This bit is always read ‘1b’ when the attached device is non-removable (DeviceRemovable[NDP]). |

### 12.4.5.5 USB HC Rh Port2 Status Register

This register is controls and reports port events on a per-port basis. The Number of Downstream Ports (NDP) represents the number of HcRhPortStatus registers that are implemented in hardware. The lower word is used to reflect the port status; the upper word reflects the status change bits. MPC5200B has NDP = 2, therefore, HcRhPort1Status (MBAR + 1054) and HcRhPort2Status (MBAR + 1058).

Some status bits are implemented with special write behavior. If a transaction (token through handshake) is in progress when a write to change port status occurs, the resulting port status change is postponed until the transaction completes. Reserved bits should always be written 0.

Address MBAR + 0x1058

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | PRSC | OCIC | PSSC | PESC | CSC |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | LSDA | PPS | Reserved | | | PRS | POCI | PSS | PES | CCS |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 12-28. USB HC Rh Port2 Status Register**

**Table 12-23. USB HC Rh Port2 Status Register Field Descriptions (Sheet 1 of 4)**

| Bits | Name | Description |
|---|---|---|
| 0:10 | — | Reserved |
| 11 | PRSC | PortResetStatusChange—bit is set at the end of the 10ms port reset signal.<br>• Writing 1 clears this bit.<br>• Writing 0 has no effect.<br>0 Port reset not complete<br>1 Port reset complete |
| 12 | OCIC | PortOverCurrentIndicatorChange—bit is valid only if overcurrent conditions are reported on a per-port basis. This bit is set when Root Hub changes the PortOverCurrentIndicator bit.<br>• Writing 1 clears this bit.<br>• Writing 0 has no effect.<br>0 No change in POCI<br>1 POCI has changed |
| 13 | PSSC | PortSuspendStatusChange—bit is set when the full resume sequence completes. Sequence includes a 20s resume pulse, LS EOP, and 3ms resychronization delay.<br>• Writing 1 clears this bit.<br>• Writing 0 has no effect.<br>This bit is also cleared when ResetStatusChange is set.<br>0 Resume not complete<br>1 Resume complete |

**Table 12-23. USB HC Rh Port2 Status Register Field Descriptions (Sheet 2 of 4)**

| Bits | Name | Description |
|---|---|---|
| 14 | PESC | PortEnableStatusChange—bit is set when hardware events cause the PES bit to be cleared.<br>• Writing 1clears this bit.<br>• Writing 0 has no effect.<br>0 No change in PES<br>1 Change in PES |
| 15 | CSC | ConnectStatusChange—bit is set whenever a connect or disconnect event occurs.<br>• Writing 1 clears this bit.<br>• Writing 0 has no effect.<br>If CCS is cleared when a SetPortReset, SetPortEnable, or SetPortSuspend write occurs, this bit is set to force the driver to re-evaluate the connection status since these writes should not occur if the port is disconnected.<br>0 No change in CCS<br>1 Change in CCS<br>If the DeviceRemovable[NDP] bit is set, this bit is set only after a Root Hub reset to notify the system that the device is attached. |
| 16:21 | — | Reserved |
| 22 | LSDA | LowSpeedDeviceAttached (read)—bit indicates the speed of the device attached to this port.<br>0 Full speed device attached<br>1 Low speed device attached<br>This field is valid only when CurrentConnectStatus is set.<br>ClearPortPower (write)<br>• Writing 1 causes HC to clear the PortPowerStatus bit.<br>• Writing 0 has no effect. |
| 23 | PPS | PortPowerStatus (read)—bit reflects the port power status, regardless of the type of power switching implemented.<br>If an overcurrent condition is detected, this bit is cleared. HCD sets this bit by writing SetPortPower or SetGlobalPower. HCD clears this bit by writing ClearPortPower or ClearGlobalPower. Which power control switches are enabled is determined by PowerSwitchingMode and PortPortControlMask[NDP].<br>In global switching mode (PSM=0), only Set/ClearGlobalPower controls this bit.<br>In per-port power switching (PSM=1), if the PortPowerControlMask[NDP] bit for the port is set, only Set/ClearPortPower commands are enabled.<br>If the mask is not set, only Set/ClearGlobalPower commands are enabled.<br>If port power is disabled, CurrentConnectStatus, PortEnableStatus, PortSuspendStatus, and PortResetStatus should be reset.<br>0 Port power is off<br>1 Port power is on<br>SetPortPower (write)<br>• Writing causes HCD to set the PortPowerStatus bit.<br>• Writing 0 has no effect.<br>If power switching is not supported, this bit always reads ‘1b’. |
| 24:26 | — | Reserved |

**Table 12-23. USB HC Rh Port2 Status Register Field Descriptions (Sheet 3 of 4)**

| Bits | Name | Description |
|---|---|---|
| 27 | PRS | PortResetStatus (read)—When this bit is set by a write to SetPortReset, port reset signaling is asserted. When reset is completed, this bit is cleared when PortResetStatusChange is set. This bit cannot be set if CurrentConnectStatus is cleared.<br>0 Port reset signal is not active<br>1 Port reset signal is active<br>SetPortReset (write)<br>• Writing 1 causes HCD to set port reset signaling.<br>• Writing 0 has no effect.<br>If CurrentConnectStatus is cleared, a write does not set PortResetStatus. Instead, it sets ConnectStatusChange. This notifies the driver that an attempt was made to reset a disconnected port. |
| 28 | POCI | PortOverCurrentIndicator (read)—bit is only valid when root hub is configured in such a way that overcurrent conditions are reported on a per-port basis.<br>If per-port overcurrent reporting is not supported, this bit is set to 0.<br>If cleared, all power operations are normal for this port.<br>If set, an overcurrent condition exists on this port. This bit always reflects the overcurrent input signal<br>0 No overcurrent condition.<br>1 Overcurrent condition detected.<br>ClearSuspendStatus (write)<br>• Writing 1 causes HC to initiate a resume.<br>• Writing 0 has no effect.<br>A resume is initiated only if PSS is set. |
| 29 | PSS | PortSuspendStatus (read)—bit indicates port is suspended or in resume sequence. It is set by a SetSuspendState write and cleared when PortSuspendStatusChange is set at the end of the resume interval.<br>This bit cannot be set if CCS. This bit is cleared when:<br>• PortResetStatusChange is set at the end of the port reset, or<br>• when HC is placed in the USBRESUME state.<br>If an upstream resume is in progress, it should propagate to the HC.<br>0 Port is not suspended<br>1 Port is suspended<br>SetPortSuspend (write)<br>• Writing 1 causes HCD to set PSS bit.<br>• Writing 0 has no effect.<br>If CurrentConnectStatus is cleared, this write does not set PSS. Instead it sets ConnectStatusChange. This notifies the driver an attempt was made to suspend a disconnected port. |

**Table 12-23. USB HC Rh Port2 Status Register Field Descriptions (Sheet 4 of 4)**

| Bits | Name | Description |
|---|---|---|
| 30 | PES | PortEnableStatus (read)—indicates whether the port is enabled or disabled.<br>The Root Hub may clear this bit when the following conditions are detected:<br>• An overcurrent condition<br>• Disconnect event<br>• Switched-off power<br>• Operational bus error (such as babble)<br>This change causes PESC to be set. HCD sets this bit by writing SetPortEnable and clears it by writing ClearPortEnable.<br>PES cannot be set when CurrentConnectStatus is cleared. If not already set, PES is set at the completion of a port reset when ResetStatusChange is set or port suspend when SuspendStatusChange is set.<br>0 Port is disabled<br>1 Port is enabled<br>SetPortEnable (write)—HCD sets PES by writing 1. Writing 0 has no effect.<br>If CCS is cleared, this write does not set PES, but instead sets CSC. This notifies the driver that an attempt was made to enable a disconnected port. |
| 31 | CCS | CurrentConnectStatus (read)—reflects current state of downstream port.<br>0 No device connected<br>1 Device connected<br>ClearPortEnable (write)—HCD writes 1 to this bit to clear PortEnableStatus bit. Writing 0 has no effect. CCS is not affected by any write.<br>**Note:** This bit is always read ‘1b’ when the attached device is non-removable (DeviceRemovable[NDP]). |

# Chapter 13
# BestComm

## 13.1 Overview

The following sections are contained in this document:

- Section 13.2, “BestComm Functional Description”
- Section 13.15, “BestComm DMA Registers”
- Section 13.16, “On-Chip SRAM”

BestComm provides an efficient, integrated approach to gathering and manipulating data sets from a broad range of communication interfaces. The DMA controller reduces the workload on the microprocessor, allowing it to continue execution of system software. The DMA microcode engine is tailored to efficiently transfer data across the internal bus architecture to memory and peripheral devices.

The DMA controller processes microcode tasks that are stored in local memory (SRAM 16 kBytes). A task is a sequence of instructions, referred to as *descriptors*, that specifies a series of data movements or manipulations. The DMA controller steps through the descriptors and executes the specified function in a similar fashion to a CPU executing a program.

For the MPC5200B, BestComm consists of SDMA and the following peripheral interfaces:

- 10/100 Fast Ethernet Controller (FEC)
- $I^2C$
- PCI
- ATA
- LocalPlus
- PSC—Peripheral Serial Controller (implementing a different mix of functionalities such as SPI, UART, CODEC 8-16-32 bits, AC97 controller, I2S, IrDA controller)

Many of the peripherals’ port pins serve multiple functions, allowing flexibility in optimizing the system to meet a specific set of integration requirements. For a description of the pin multiplexing scheme and supported functions, refer to Chapter 2, “Signal Descriptions”.

Other peripheral functions are included in MPC5200B, but are not directly supported by BestComm. These peripherals include:

- A separate Serial Peripheral Interface (SPI), which:
  - Supports a 6.25MHz rate as a master
  - Supports a 12.5MHz rate as a slave
- USB Host/Hub controller
- MSCAN controller
- General Purposes Timers

## 13.2 BestComm Functional Description

The BestComm I/O subsystem consists of the following:

- A BestComm DMA Controller
- An on-chip 16 kBytes SRAM
- A set of peripheral interface modules with DMA controllable:
  - Transmit (Tx)
  - Receive (Rx)

The BestComm unit provides an interrupt control and data movement interface. The Interface is on a separate peripheral bus to several on-chip peripheral functions. This independent control of data movement leaves the e300 core free to concentrate on higher level activities, which increases overall system performance.

BestComm DMA can control data movement on the following peripherals and interfaces:

- PCI bus
- ATA Controller
- Ethernet
- PSC
- $I^2C$
- IrDA
- LP bus interface

**NOTE**

It is possible for the BESTComm DMA to produce misaligned word addresses on its Slave and Comm bus. These accesses occur due to incorrect program code executed by the BestComm unit. Any misaligned access will be incorrectly processed on the internal SRAM bus and the Comm bus.

The work around is to avoid using misaligned accesses. That is, BestComm program code must be written such that misaligned word accesses will not occur.

BestComm DMA performs general purpose DMA transfers. Most data transactions are between the peripheral/interface (typically a FIFO) and the system SDRAM.

BestComm allows up to 16 tasks to run simultaneously under the control of up to 32 DMA hardware requestors, user selectable from a possible 64 DMA request sources.

A hardware logic unit capable of basic logic operations (boolean arbitrary operations, shift, byte swap) plus some precoded CRC (CRC-16, CRC-CCITT, CRC-32, Internet Checksum) is also integrated in the SDMA engine.

BestComm uses internal buffers to prefetch reads and post writes such that bursting is used whenever possible. This optimizes both internal and external bus activity.

Speculative reads from system SDRAM may also be enabled to increase performance.

FIFO interfaces are implemented between the DMA and each peripheral/interface. As FIFOs are filled or emptied, automatic requests are made to the DMA unit. Based on programmable water mark levels (called ALARM and GRANULARITY level), the DMA unit moves data to and from the FIFOs. This method insures uninterrupted data movement at the given peripheral/interface rate.

## 13.3 Features Summary

- A programmatic, deterministic capability for managing bus resources while servicing many data streams with individual latency and processing requirements.
- Single cycle access of peripheral and memory data.
- Support for up to 16 simultaneously enabled tasks (channels).
- Support for up to 32 separate DMA requestors at a time, user selectable from a possible 64 DMA request sources.
- Support for operations with up to 12 sources, or 11 sources and 1 destination.
- Simultaneous 32-bit reads and writes.
- Checksum generation.
- Endian conversion.
- Chaining/Scatter-gather capability.
- Support for packet-based I/O protocols (limitation might be dictated by performance when too much control is implemented within the task).
- External DMA Request.
- External DMA breakpoint.

## 13.4 Descriptors

The DMA controller interprets a series of descriptors that specifies a sequence of data movements and manipulations. A collection of these descriptors is much like a program. The two types of descriptors are Loop Control Descriptors (LCDs) and Data Routing Descriptors (DRDs). These descriptors allow a “for”-loop programming style for the SDMA engine.

The LCDs specify the index variables (memory pointers, byte counters, etc.) along with the termination and increment values, while the DRDs specify the nature of the operation to perform.

## 13.5 Tasks

A task is a microcode program that embodies a desired function. An example could be to gather an ethernet frame, store it in memory and interrupt the processor when done. The multi-channel DMA supports sixteen simultaneously enabled tasks. By dynamically swapping task pointers in the task table, an unlimited number of tasks could be supported.

## 13.6 Memory Map/ Register Definitions

Memory organization is described in the register array pointed to by the Task Base Address Register (TaskBAR).

The TaskBAR identifies a location for a table of pointers to multi-channel DMA tasks (Task TABLE or Entry Table).

Each task has an entry (8 long words) that contains information about the microcode's location (start address and stop address) in memory as well as pointers to the variable table to be used in the task, the Function Descriptor Table for the logic functions used within the task, the Context Save area used during task switch/swap and some specific flags to enable performance affecting modes such as speculative reads, prefetch enable, readline and combined write.

A task's code should always be loaded into SRAM as the SDMA engine can fetch its descriptors from this internal memory with one cycle access per instruction. It is not recommended to place the code in SDRAM as there will then be a few overhead clocks which are needed to load the SDMA instruction unit.

## 13.7 Task Table (Entry Table)

The Task Table (or Entry Table) is a memory region containing pointers to each SDMA task. A Task Table Base Address Register (taskBAR) sets the location of the Task Table itself. Each entry in the Task Table contains pointers to the task's first descriptor, last descriptor, Variable Table, and other task-specific information.

## 13.8 Task Descriptor Table

Each Task Descriptor Table is a memory region containing the descriptors that comprise the task. The pointers in the Task Table define the beginning and end of each Task Descriptor Table.

## 13.9 Variable Table

Each task has a private 32-word Variable Table, where a word is four bytes (32 bits). According to the application requirements, the user initializes some of the words in the Variable Table as follows. The first 24 words are for pointers, counter values and initial data. The DMA Engine manipulates these variables as it executes loops. The next 8 words hold words-aligned, two-byte ("short word" or 16 bit word) increment variables.

## 13.10 Function Descriptor Table

An area of 256 bytes divided in 4 groups of 64 bytes. Each group can represent a set of 16 different Logic Functions belonging to a single execution unit. Every function is encoded with a single word (32 bits).

The implemented SDMA engine uses only one out of four potential Execution Units, execution unit 3, so all the functions needed by the task will be encoded in the third group (starting at offset 0xC0 from the start address of the Function Descriptor Table). The other words are reserved and must be written to '0' to maintain memory alignment.

For space optimization, tasks which use the same logic functions could share a single Function Descriptor Table avoiding the redundancy of re-writing the same table many times in SRAM.

## 13.11 Context Save Area

This is an area allocated for each task to allow the SDMA engine to save vital data (such as index values, etc.) during a task switch operation to allow later restoration.

The context save area should never be used or modified by the user as it is managed directly by the SDMA engine.

## 13.12 External DMA Request

BestComm supports 64 user selectable request sources. 32 of them are controllable via GPIO pins, see SDMA Request MuxControl Register. This GPIO group is split up into two different kind of GPIO's, 24 simple and 8 simple interrupt GPIO's. The differences are:

- Simple GPIO's: The external request event must be kept asserted until the first, intended data transaction is executed.
- Simple interrupt GPIO's: The external request event can be deasserted before the first, intended data transaction has started. Additionally, the external request can generate an interrupt for the e300 core.

The GPIO, which is intended to generate a DMA request, must be enabled and set up as input, in both cases (see Section 7.3, "General Purpose I/O (GPIO)").

**NOTE**

MPC5200B doesn't support external DMA Acknowledge.

## 13.13 External DMA Breakpoint

The SDMA engine can be halted if the Enable Breakpoint (EB) and the Enable External Breakpoint (E) bits of the SDMA Debug Module Control Register are set and the 603e e300 core hits an Instruction Address Breakpoint or a Data Address Breakpoint.

## 13.14 BestComm XLB Address Snooping

BestComm prefetches data from the XLB into 4 32-Byte wide Read Line Buffers. A buffer will be invalidated, if the BestComm XLB Address Snooping (BSDIS) is enabled, see Chapter 16, "XLB Arbiter", and a write operation on the XLB to the prefetched data address happens. No invalidation of the buffer will happen if the BSDIS bit is set. BestComm will still use the old prefetched data.

## 13.15 BestComm DMA Registers

A register overview is provided in Section 3.2, "Internal Register Memory Map".

### 13.15.1 Register Descriptions

Hyperlinks to the BestComm DMA registers are provided below:

- SDMA Task Bar Register (0x1200)
- SDMA Current Pointer Register (0x1204)
- SDMA End Pointer Register (0x1208)
- SDMA Variable Pointer Register (0x120C)
- SDMA Interrupt Vector, PTD Control Register Field Descriptions (0x1210)
- SDMA Interrupt Pending Register (0x1214)
- SDMA Interrupt Mask Register (0x1218)
- SDMA Task Control 0 and 1 Registers (0x121C)
- SDMA Task Control 2 and 3 Registers (0x1220)
- SDMA Task Control 4 and 5 Registers (0x1224)
- SDMA Task Control 6 and 7 Registers (0x1228)
- SDMA Task Control 8 and 9 Registers (0x122C)
- SDMA Task Control A and B Registers (0x1230)
- SDMA Task Control C and D Registers (0x1234)
- SDMA Task Control E and F Registers (0x1238)
- SDMA Initiator Priority 0, 1, 2, and 3 Registers (0x123C)
- SDMA Initiator Priority 4, 5, 6, and 7 Registers (0x1240)
- SDMA Initiator Priority 8, 9, 10, and 11 Registers (0x1244)
- SDMA Initiator Priority 12, 13, 14, and 15 Registers (0x1248)
- SDMA Initiator Priority 16, 17, 18, and 19 Registers (0x124C)
- SDMA Initiator Priority 20, 21, 22, and 23 Registers (0x1250)
- SDMA Initiator Priority 24, 25, 26, and 27 Registers (0x1254)
- SDMA Initiator Priority 28, 29, 30, and 31 Registers (0x1258)
- SDMA Request MuxControl (0x125C)
- SDMA Task Size 0/1 Field Descriptions (0x1260)
- SDMA Task Size 0/1 Field Descriptions (0x1264)

- SDMA Debug Module Comparator 1, Value1 Register (0x1270)
- SDMA Debug Module Comparator 2, Value2 Register (0x1274)
- SDMA Debug Module Control Register (0x1278)
- SDMA Debug Module Status Register (0x127C)

### 13.15.1.1 SDMA Task Bar Register

Address MBAR + 0x1200

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | taskBar | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | taskBar | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-1. SDMA Task Bar Register**

**Table 13-1. SDMA Task Bar Register Field Description**

| Bit | Name | Description |
|---|---|---|
| 0:31 | taskBar | TaskBAR is the pointer to the base address of the Task Table (Entry Table) |

### 13.15.1.2 SDMA Current Pointer Register

Address MBAR + 0x1204

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | CurrentPointer | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | CurrentPointer | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-2. SDMA Current Pointer Register**

**Table 13-2. SDMA Current Pointer Register Field Description**

| Bit | Name | Description |
|---|---|---|
| 0:31 | CurrentPointer | CurrentPointer contains the address of the currently executing DMA descriptor. |

### 13.15.1.3 SDMA End Pointer Register

Address MBAR + 0x1208

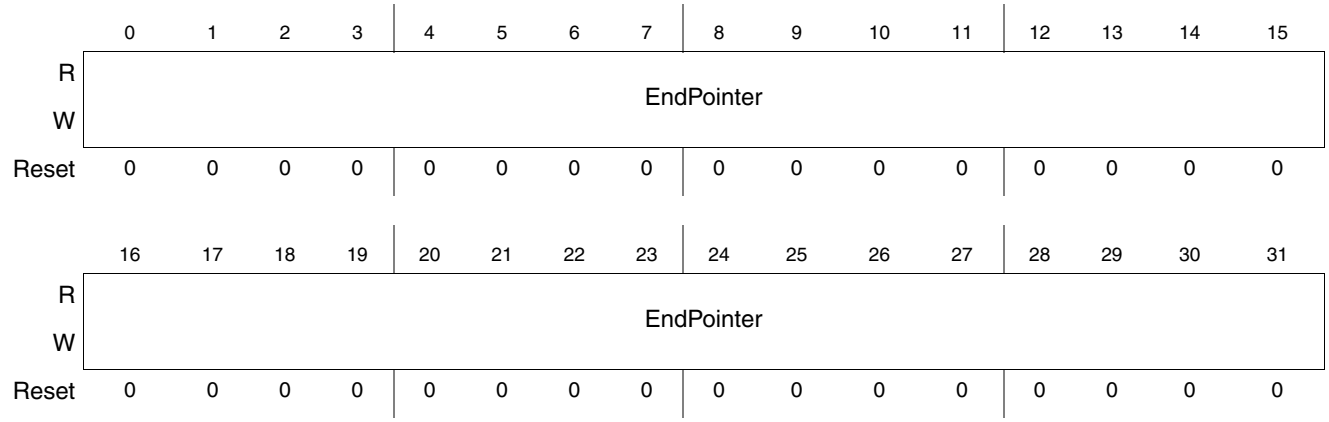



**Figure 13-3. SDMA End Pointer Register**

**Table 13-3. SDMA End Pointer Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:31 | endPointer | EndPointer contains the address of the last descriptor in the currently executing SDMA task. |

### 13.15.1.4 SDMA Variable Pointer Register

Address MBAR + 0x120C

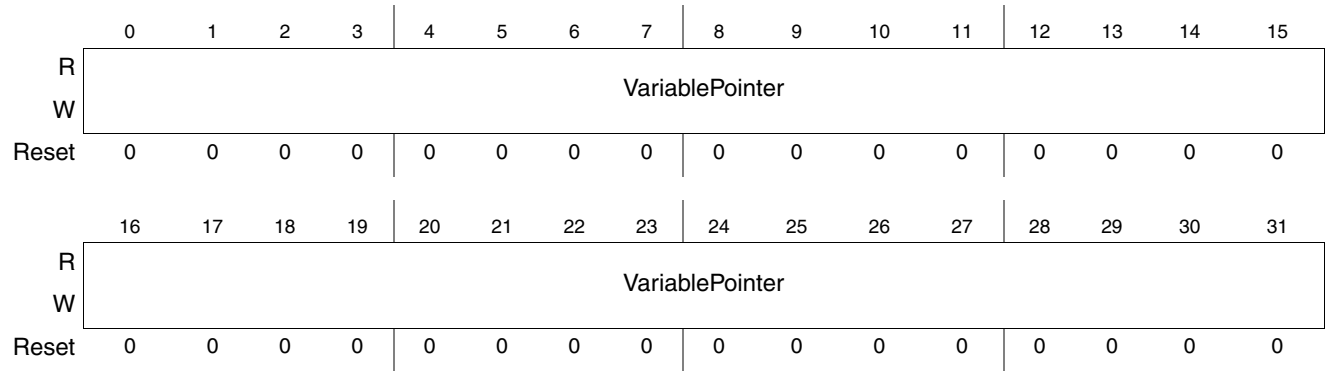



**Figure 13-4. SDMA Variable Pointer Register**

**Table 13-4. SDMA Variable Pointer Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:31 | variablePointer | VariablePointer contains the starting address of the variable table for the currently executing task. |

### 13.15.1.5 SDMA Interrupt Vector, PTD Control Register

Address MBAR + 0x1210

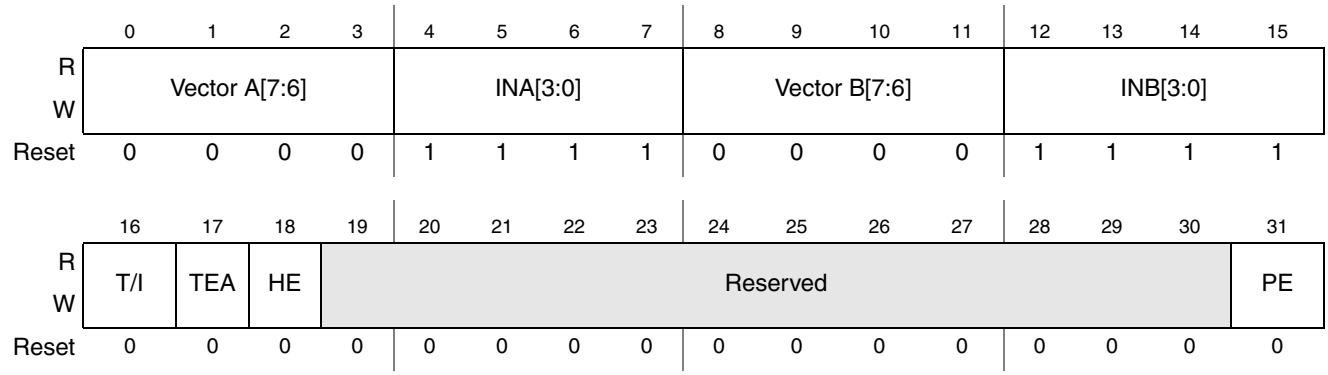



**Figure 13-5. SDMA Interrupt Vector, PTD Control Register**

**Table 13-5. SDMA Interrupt Vector, PTD Control Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | IntVect1 | The Interrupt Vector register is used during interrupt acknowledge read cycles. The high order four bits are programmed by the user, and the low order four bits are decoded from either the current task number or execution unit. If any task interrupts are asserted, Interrupt Vector 1 is driven during the interrupt acknowledge cycle. If the task interrupts are negated and the execution unit interrupts are asserted, Interrupt Vector 2 is driven during the interrupt acknowledge cycle. The registers are set to the uninitialized vector $0F by system reset.<br>The interrupt A number is prioritized with IPR[15] the highest and IPR[0] the lowest. If all interrupt mask bits are set, then INA[3:0] = 1111 is read from this location.<br>The interrupt B number is prioritized with the dbgInterrupt as the highest and euInterrupt[0] the lowest. If all interrupt mask bits are set, then INB[3:0] = 1111 is read from this location. |
| 8:15 | IntVect2 | See above |
| 16 | T/I | T/I: Task/Iniator priority. Set to ‘1’ to switch to “TASK priority” control; set to ‘0’ to revert to INITIATOR (Requestor) Priority mode.<br>The priority level of either the TASK or the initiator is set in the register IPR0 through IPR31 |
| 17 | TEA | TEA: If set to ‘1’ a TEA received by BestComm will be ignored and the task will NOT be halted. TEA indication can still trigger an interrupt if the proper mask bit is cleared in the Interrupt Mask Register and the TEA status bit plus the TASK number of the task which received the TEA are still updated in the Interrupt Pending Register. |
| 18 | HE | HE = 1; allows smartDMA higher task number same request priority to block current task, and allow arbitration.<br>HE = 0; disables higher task number from blocking. This bit is cleared by reset. |
| 19:30 | — | Reserved |
| 31 | PE | Prefetch Disable: set to ‘1’ to disable prefetch. Set to ‘0’ to enable prefetch on CommBus |

### 13.15.1.6 SDMA Interrupt Pending Register

Address MBAR + 0x1214

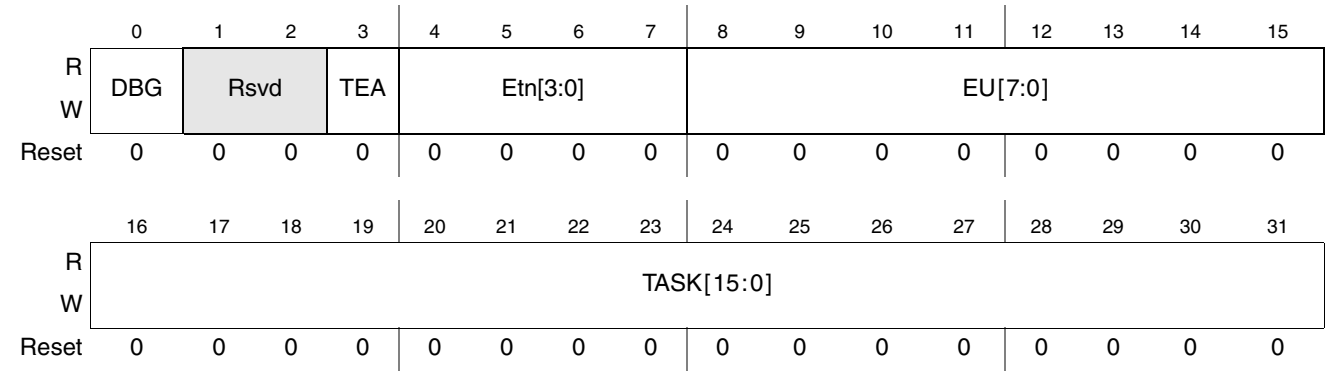



**Figure 13-6. SDMA Interrupt Pending Register**

**Table 13-6. SDMA Interrupt Pending Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | DBG | Debug |
| 1:2 | — | Reserved |
| 3 | TEA | A TEA has been received by the currently running task. The corresponding task number is written in the Error Task Number field |
| 4:7 | Etn[3:0] | Error Task Number: when a TEA is received by the currently executing task its corresponding number is indicated here. If the TEA bit of the PtdControl register is set then the task will **not** be halted. If the TEA Msk bit in the Mask register is set then **no** interrupt to the core will be generated. |
| 8:15 | EU[7-0] | Execution Unit: only EU3 is valid for MPC5200B |
| 16:31 | TASK[15:0] | Each bit corresponds to an interrupt source defined by the task number or execution unit. This register contains a registered copy of the interrupt signal that the interrupting source generates. The corresponding bit in the register reflects the state of the interrupt signal even if the corresponding mask bit is set. An interrupt is masked by setting the corresponding bit in the IntMask register. A bit is cleared by writing 1 to that bit location. Writing 0 has no effect. At system reset, all bits are initialized to logic 0.<br>0 The corresponding interrupt source is **not** pending.<br>1 The corresponding interrupt source is pending. |

### 13.15.1.7 SDMA Interrupt Mask Register

Address MBAR + 0x1218

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | DBG | Reserved | | TEA Msk | Reserved | | | | EU[7:0] | | | | | | | |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TASK[15:0] | | | | | | | | | | | | | | | |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Figure 13-7. SDMA Interrupt Mask Register**

**Table 13-7. SDMA Interrupt Mask Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | DBG | Debug: set to ‘1’ to mask the “debug” interrupt (see the SDMA Debug Control Register) |
| 1:2 | — | Reserved |
| 3 | TEA Msk | TEA Mask: set to ‘1’ to mask the TEA. If set to ‘1’ and a TEA is received in the currently executing Task an interrupt is generated. |
| 4:7 | — | Reserved |
| 8:15 | EU[x] | Execution Unit: Only EU3 is present in MPC5200B |
| 16:31 | TASK[15:0] | Each bit corresponds to an interrupt source defined by the task number or execution unit.<br>An interrupt is masked by setting the corresponding bit. At system reset, all bits are initialized to logic 1.<br>0 The corresponding interrupt source is **not** masked.<br>1 The corresponding interrupt source is masked (no interrupt is generated). |

### 13.15.1.8 SDMA Task Control 0 Register SDMA Task Control 1 Register

Address MBAR + 0x121C, 0x121E

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | En | Val | Alw Init | IN[4:0] | | | | | Auto Start | High En | Hold | Rsvd | AS [3:0] | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TCR1 (same as for TCR0) | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-8. SDMA Task Control 0 and 1 Registers**

**Table 13-8. SDMA Task Control 0 and 1 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | EN | Each of the sixteen tasks has an associated task control register. Only one register is shown. At system reset, all bits are initialized to logic zeros.<br>Enable =Task Enable<br>0 Disabled<br>1 Enabled<br>This bit can be set or cleared by the programmer at any time when a task is enabled or disabled. This bit is also set by the PTD logic if the auto-restart bit is set and the task completes. |
| 1 | Val | Valid—Initiator Number is Valid<br>0 Initiator is not valid<br>1 Initiator is valid<br>This bit is set by the engine logic when it obtains the requestor value from the first DRD that is parsed. This bit is cleared by the logic when the task completes. At system reset, this bit is cleared. |
| 2 | Alw Init | Always Init—Decode of the always initiator<br>0 The always initiator is not being used<br>1 The always initiator is being used<br>This bit is a status bit only and is set and cleared by writing the initiator number into the Task Control Register. |
| 3:7 | IN[4:0] | InitNum[4:0]—Initiator number from task descriptor<br>These bits are registered when the SDMA engine has parsed the first DRD to obtain the requestor number. These bits are cleared by system reset. These bits can be written by the programmer when the Hold Init Num bit is set or being set and the task is not enabled.<br>At system reset, these bits are cleared. |
| 8 | Auto Start | Auto-Start—Task Start<br>0Task will not restart within program control<br>1 Task will restart at end of task automatically.<br>This bit can be set or cleared by the programmer at any time. This bit is also cleared if the SDMA engine encounters an error in the task. At system reset, this bit is cleared. |

**Table 13-8. SDMA Task Control 0 and 1 Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 9 | High En | High-Enable—High Priority Task Enable<br>0 Normal task enable control<br>1 High priority task enable control<br>This bit can be set or cleared by the programmer at any time. This bit enables the SDMA to give priority to the enabled task function over running a task. At system reset, this bit is cleared. |
| 10 | Hold | Hold Init Num- Hold initiator number<br>0 Allow the SDMA engine to update initiator number for task<br>1 Keep current initiator number.<br>This bit allows the initiator number to be set by the programmer and held for the complete task. The SDMA can not overwrite the programmed initiator except for the use of the always initiator which is contained in a separate control bit. |
| 11 | — | Reserved |
| 12-15 | AS[3:0] | ASNum[3:0]—Auto-Start Task Number<br>These four bits contain the task number which will be auto-started when the Auto-Start control bit is set. At system reset, these bits are cleared. |
| 16:31 | TCR1 | Task control register for task 1. Same bit layout as for TCR0 |

## 13.15.1.9 SDMA Task Control 2 Register SDMA Task Control 3 Register

Address MBAR + 0x1220, 0x1222

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TCR2 | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TCR3 | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-9. SDMA Task Control 2 and 3 Registers**

**Table 13-9. SDMA Task Control 2 and 3 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:15 | TCR2 | Task control register for task 2. Same bit layout as for TCR0 |
| 16:31 | TCR3 | Task control register for task 3. Same bit layout as for TCR0 |

### 13.15.1.10 SDMA Task Control 4 Register SDMA Task Control 5 Register

Address MBAR + 0x1224, 0x1226

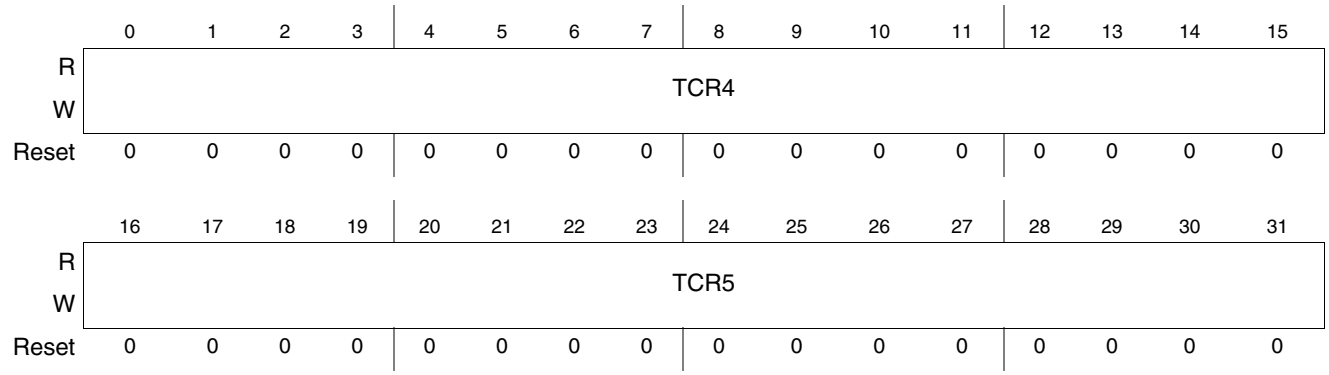



**Figure 13-10. SDMA Task Control 4 and 5 Registers**

**Table 13-10. SDMA Task Control 4 and 5 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:15 | TCR4 | Task control register for task 4. Same bit layout as for TCR0 |
| 16:31 | TCR5 | Task control register for task 5. Same bit layout as for TCR0 |

### 13.15.1.11 SDMA Task Control 6 Register SDMA Task Control 7 Register

Address MBAR + 0x1228, 0x122A

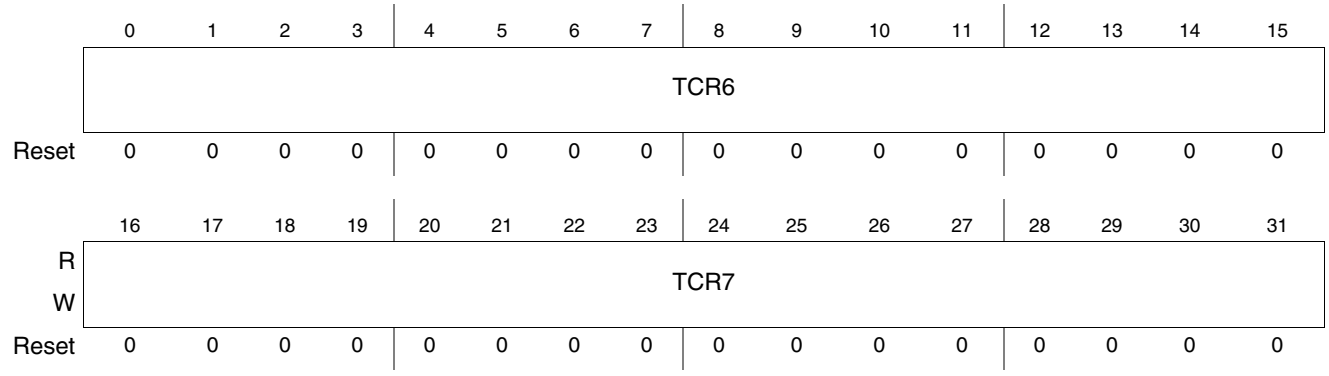



**Figure 13-11. SDMA Task Control 6 and 7 Registers**

**Table 13-11. SDMA Task Control 6 and 7 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:15 | TCR6 | Task control register for task 6. Same bit layout as for TCR0 |
| 16:31 | TCR7 | Task control register for task 7. Same bit layout as for TCR0 |

### 13.15.1.12 SDMA Task Control 8 Register SDMA Task Control 9 Register

Address MBAR + 0x122C, 0x122E

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TCR8 | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TCR9 | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-12. SDMA Task Control 8 and 9 Registers**

**Table 13-12. SDMA Task Control 8 and 9 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:15 | TCR8 | Task control register for task 8. Same bit layout as for TCR0 |
| 16:31 | TCR9 | Task control register for task 9. Same bit layout as for TCR0 |

### 13.15.1.13 SDMA Task Control A Register SDMA Task Control B Register

Address MBAR + 0x1230, 0x1232

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TCRA | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TCRB | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-13. SDMA Task Control A and B Registers**

**Table 13-13. SDMA Task Control A and B Register Field Description**

| Bit | Name | Description |
|---|---|---|
| 0:15 | TCRA | Task control register for task 10. Same bit layout as for TCR0 |
| 16:31 | TCRB | Task control register for task 11. Same bit layout as for TCR0 |

### 13.15.1.14 SDMA Task Control C Register SDMA Task Control D Register

Address MBAR + 0x1234, 0x1236

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TCRC | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TCRD | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-14. SDMA Task Control C and D Registers**

**Table 13-14. SDMA Task Control C and D Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:15 | TCRC | Task control register for task 12. Same bit layout as for TCR0 |
| 16:31 | TCRD | Task control register for task 13. Same bit layout as for TCR0 |

### 13.15.1.15 SDMA Task Control E Register SDMA Task Control F Register

Address MBAR + 0x1238, 0x123A

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TCRE | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TCRF | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-15. SDMA Task Control E and F Registers**

**Table 13-15. SDMA Task Control E and F Registers**

| Bit | Name | Description |
|---|---|---|
| 0:15 | TCRE | Task control register for task 14. Same bit layout as for TCR0 |
| 16:31 | TCRF | Task control register for task 15. Same bit layout as for TCR0 |

### 13.15.1.16 SDMA Initiator Priority 0 Register
### SDMA Initiator Priority 1 Register
### SDMA Initiator Priority 2 Register
### SDMA Initiator Priority 3 Register

Address MBAR + 0x123C, 0x123D, 0x128E, 0x123F

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR0 Hold | Reserved | | | | Prior [2:0] | | | IPR1 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR2 | | | | | | | | IPR3 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-16. SDMA Initiator Priority 0, 1, 2, and 3 Registers**

**Table 13-16. SDMA Initiator Priority 0, 1, 2, and 3 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| Each of the thirty-two initiators has an associated priority level. Only one register is shown. All bits are set to ‘0 at reset. | | |
| 0 | IPR0 Hold | Hold—Keep current priority of initiator<br>0 = Allow higher priority initiator to block current initiator<br>1 = Hold current initiator priority level<br>This bit can be set or cleared by the programmer at any time. This bit allows the current initiator to hold priority until the initiator has negated or the task has finished. When this bit is cleared, an initiator with a higher priority will block the current initiator and force arbitration. At system reset, this bit is cleared. |
| 1:4 | — | Reserved |
| 5:7 | Prior[2:0] | InitPrior[2:0]—Initiator/Task priority level.<br>These bits can be set by the programmer at any time. These bits control the priority of the requestor/task which will be serviced next depending on the setting of the T/I bit in the PtdControl register.<br>The highest priority is level 7. The lower priority is level 0. If more than one initiator/task contains the same priority then the order of the task within the Task table (task 7 highest to task 0 lowest) will set the priority. |
| 8:15 | IPR1 | Initiator Priority register for initiator 1 (or Task1 if PtdControl[16]=1).<br>Same bit layout as IPR0 |
| 16:23 | IPR2 | Initiator Priority register for initiator 2.(or Task2 if PtdControl[16]=1)<br>Same bit layout as IPR0 |
| 24:31 | IPR3 | Initiator Priority register for initiator 3.(or Task3 if PtdControl[16]=1)<br>Same bit layout as IPR0 |

### 13.15.1.17 SDMA Initiator Priority 4 Register
### SDMA Initiator Priority 5 Register
### SDMA Initiator Priority 6 Register
### SDMA Initiator Priority 7 Register

Address MBAR + 0x1240, 0x1241, 0x1242, 0x1243

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR4 | | | | | | | | IPR5 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR6 | | | | | | | | IPR7 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-17. SDMA Initiator Priority 4, 5, 6, and 7 Registers**

**Table 13-17. SDMA Initiator Priority 4, 5, 6, and 7 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | IPR4 | Initiator Priority register for initiator 4 (or Task4 if PtdControl[16]=1)<br>Same bit layout as IPR0 |
| 8:15 | IPR5 | Initiator Priority register for initiator 5 (or Task5 if PtdControl[16]=1)<br>Same bit layout as IPR0 |
| 16:23 | IPR6 | Initiator Priority register for initiator 6 (or Task6 if PtdControl[16]=1)<br>Same bit layout as IPR0 |
| 24:31 | IPR7 | Initiator Priority register for initiator 7 (or Task7 if PtdControl[16]=1)<br>Same bit layout as IPR0 |

### 13.15.1.18 SDMA Initiator Priority 8 Register
### SDMA Initiator Priority 9 Register
### SDMA Initiator Priority 10 Register
### SDMA Initiator Priority 11 Register

Address MBAR + 0x1244, 0x1245, 0x1246, 0x1247

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR8 | | | | | | | | IPR9 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR10 | | | | | | | | IPR11 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-18. SDMA Initiator Priority 8, 9, 10, and 11 Registers**

**Table 13-18. SDMA Initiator Priority 8, 9, 10, and 11 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | IPR8 | Initiator Priority register for initiator 8 (or Task8 if PtdControl[16]=1)<br>Same bit layout as IPR0 |
| 8:15 | IPR9 | Initiator Priority register for initiator 9 (or Task9 if PtdControl[16]=1)<br>Same bit layout as IPR0 |
| 16:23 | IPR10 | Initiator Priority register for initiator 10 (or Task10 if PtdControl[16]=1)<br>Same bit layout as IPR0 |
| 24:31 | IPR11 | Initiator Priority register for initiator 11 (or Task11 if PtdControl[16]=1)<br>Same bit layout as IPR0 |

### 13.15.1.19 SDMA Initiator Priority 12 Register
### SDMA Initiator Priority 13 Register
### SDMA Initiator Priority 14 Register
### SDMA Initiator Priority 15 Register

Address MBAR + 0x1248, 0x1249, 0x124A, 0x124B

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR12 | | | | | | | | IPR13 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR14 | | | | | | | | IPR15 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-19. SDMA Initiator Priority 12, 13, 14, and 15 Registers**

**Table 13-19. SDMA Initiator Priority 12, 13, 14, and 15 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | IPR12 | Initiator Priority register for initiator 12 (or Task12 if PtdControl[16]=1)<br>Same bit layout as IPR0 |
| 8:15 | IPR13 | Initiator Priority register for initiator 13 (or Task13 if PtdControl[16]=1)<br>Same bit layout as IPR0 |
| 16:23 | IPR14 | Initiator Priority register for initiator 14 (or Task14 if PtdControl[16]=1)<br>Same bit layout as IPR0 |
| 24:31 | IPR15 | Initiator Priority register for initiator 15 (or Task15 if PtdControl[16]=1)<br>Same bit layout as IPR0 |

### 13.15.1.20 SDMA Initiator Priority 16 Register
### SDMA Initiator Priority 17 Register
### SDMA Initiator Priority 18 Register
### SDMA Initiator Priority 19 Register

Address MBAR + 0x124C, 0x124D, 0x124E, 0x124F

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR16 | | | | | | | | IPR17 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR18 | | | | | | | | IPR19 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-20. SDMA Initiator Priority 16, 17, 18, and 19 Registers**

**Table 13-20. SDMA Initiator Priority 16, 17, 18, and 19 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | IPR16 | Initiator Priority register for initiator 16.<br>Same bit layout as IPR0 |
| 8:15 | IPR17 | Initiator Priority register for initiator 17.<br>Same bit layout as IPR0 |
| 16:23 | IPR18 | Initiator Priority register for initiator 18.<br>Same bit layout as IPR0 |
| 24:31 | IPR19 | Initiator Priority register for initiator 19.<br>Same bit layout as IPR0 |

### 13.15.1.21 SDMA Initiator Priority 20 Register
### SDMA Initiator Priority 21 Register
### SDMA Initiator Priority 22 Register
### SDMA Initiator Priority 23 Register

Address MBAR + 0x1250, 0x1251, 0x1252, 0x1253

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR20 | | | | | | | | IPR21 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR22 | | | | | | | | IPR23 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-21. SDMA Initiator Priority 20, 21, 22, and 23 Registers**

**Table 13-21. SDMA Initiator Priority 20, 21, 22, and 23 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | IPR20 | Initiator Priority register for initiator 20.<br>Same bit layout as IPR0 |
| 8:15 | IPR21 | Initiator Priority register for initiator 21.<br>Same bit layout as IPR0 |
| 16:23 | IPR22 | Initiator Priority register for initiator 22.<br>Same bit layout as IPR0 |
| 24:31 | IPR23 | Initiator Priority register for initiator 23.<br>Same bit layout as IPR0 |

## 13.15.1.22 SDMA Initiator Priority 24 Register
## SDMA Initiator Priority 25 Register
## SDMA Initiator Priority 26 Register
## SDMA Initiator Priority 27 Register

Address MBAR + 0x1254, 0x1255, 0x1256, 0x1257

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR24 | | | | | | | | IPR25 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR26 | | | | | | | | IPR27 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-22. SDMA Initiator Priority 24, 25, 26, and 27 Registers**

**Table 13-22. SDMA Initiator Priority 24, 25, 26, and 27 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | IPR24 | Initiator Priority register for initiator 24.<br>Same bit layout as IPR0 |
| 8:15 | IPR25 | Initiator Priority register for initiator 25.<br>Same bit layout as IPR0 |
| 16:23 | IPR26 | Initiator Priority register for initiator 26.<br>Same bit layout as IPR0 |
| 24:31 | IPR27 | Initiator Priority register for initiator 27.<br>Same bit layout as IPR0 |

### 13.15.1.23 SDMA Initiator Priority 28 Register
### SDMA Initiator Priority 29 Register
### SDMA Initiator Priority 30 Register
### SDMA Initiator Priority 31 Register

Address MBAR + 0x1258, 0x1259, 0x125A, 0x125B

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR28 | | | | | | | | IPR29 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IPR30 | | | | | | | | IPR31 | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-23. SDMA Initiator Priority 28, 29, 30, and 31 Registers**

**Table 13-23. SDMA Initiator Priority 28, 29, 30, and 31 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | IPR28 | Initiator Priority register for initiator 28.<br>Same bit layout as IPR0 |
| 8:15 | IPR29 | Initiator Priority register for initiator 29.<br>Same bit layout as IPR0 |
| 16:23 | IPR30 | Initiator Priority register for initiator 30.<br>Same bit layout as IPR0 |
| 24:31 | IPR31 | Initiator Priority register for initiator 31.<br>Same bit layout as IPR0 |

## 13.15.1.24 SDMA Requestor MuxControl

Address MBAR + 0x125C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Req31 | | Req30 | | Req29 | | Req28 | | Req27 | | Req26 | | Req25 | | Req24 | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Req23 | | Req22 | | Req21 | | Req20 | | Req19 | | Req18 | | Req17 | | Req16 | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-24. SDMA Request MuxControl**

**Table 13-24. SDMA Request MuxControl Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | Req31 | 00 Requestor (RESERVED)<br>01 GPIO_PSC2_3<br>10 GPIO_IRDA_1<br>11 Always Requestor 31 |
| 2:3 | Req30 | 00 Requestor (RESERVED)<br>01 GPIO_PSC2_2<br>10 GPIO_IRDA_0<br>11 Always Requestor 30 |
| 4:5 | Req29 | 00 Requestor (RESERVED)<br>01 GPIO_PSC2_1<br>10 GPIO_ETH_3<br>11 Always Requestor 29 |
| 6:7 | Req28 | 00 Requestor (RESERVED)<br>01 GPIO_PSC2_0<br>10 GPIO_ETH_2<br>11 Always Requestor 28 |
| 8:9 | Req27 | 00 Requestor (RESERVED)<br>01 GPIO_PSC1_3<br>10 GPIO_ETH_1<br>11 Always Requestor 27 |
| 10:11 | Req26 | 00 Requestor IrDA TX (PSC_6)<br>01 GPIO_PSC1_2<br>10 GPIO_ETH_0<br>11 Always Requestor 26 |
| 12:13 | Req25 | 00 Requestor IrDA RX (PSC_6)<br>01 GPIO_PSC1_1<br>10 GPIO_USB_3<br>11 Always Requestor 25 |
| 14:15 | Req24 | 00 Requestor I2C1_TX<br>01 GPIO_PSC1_0<br>10 GPIO_USB_2<br>11 Always Requestor 24 |

**Table 13-24. SDMA Request MuxControl Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 16:17 | Req23 | 00 Requestor I2C1_RX<br>01 GPIO_SINT_7<br>10 GPIO_USB_1<br>11 Always Requestor 23 |
| 18:19 | Req22 | 00 Requestor I2C2_TX<br>01 GPIO_SINT_6<br>10 GPIO_USB_0<br>11 Always Requestor 22 |
| 20:21 | Req21 | 00 Requestor I2C2_RX<br>01 GPIO_SINT_5<br>10 GPIO_PSC3_5<br>11 Always Requestor 21 |
| 22:23 | Req20 | 00 Requestor PSC4_TX<br>01 GPIO_SINT_4<br>10 GPIO_PSC3_4<br>11 Always Requestor 20 |
| 24:25 | Req19 | 00 Requestor PSC4_RX<br>01 GPIO_SINT_3<br>10 GPIO_PSC3_3<br>11 Always Requestor 19 |
| 26:27 | Req18 | 00 Requestor PSC5_TX<br>01 GPIO_SINT_2<br>10 GPIO_PSC3_2<br>11 Always Requestor 18 |
| 28:29 | Req17 | 00 Requestor PSC5_RX<br>01 GPIO_SINT_1<br>10 GPIO_PSC3_1<br>11 Always Requestor 17 |
| 30:31 | Req16 | 00 Requestor LP<br>01 GPIO_SINT_0<br>10 GPIO_PSC3_0<br>11 Always Requestor 16 |

The remaining 16 requestors are fixed as follows:

**Table 13-25. FIxed Requestors Table**

| Requestor | Peripheral |
|---|---|
| REQ15 | (RESERVED) |
| REQ14 | PSC1_TX |
| REQ13 | PSC1_RX |
| REQ12 | PSC2_TX |
| REQ11 | PSC2_RX |
| REQ10 | PSC3_TX |
| REQ9 | PSC3_RX |
| REQ8 | PCI TX |
| REQ7 | PCI RX |
| REQ6 | ATA TX |
| REQ5 | ATA RX |
| REQ4 | FEC TX |
| REQ3 | FEC RX |
| REQ2 | (RESERVED) |
| REQ1 | (RESERVED) |
| REQ0 | ALWAYS |

## 13.15.1.25 SDMA Task Size0 SDMA Task Size 1

Address MBAR + 0x1260, 0x1264

| Bits | 0,4,8,12, 16,20,24,28 | 1,5,9,13, 17,21,25,29 | 2,6,10,14, 18,22,26,30 | 3,7,1115 19,23,27,31 |
|---|---|---|---|---|
| R<br>W | srcSize[1] | srcSize[0] | dstSize[1] | dstSize[0] |
| Reset | At reset all Bits are set to 0 | | | |

**Figure 13-25. SDMA Task Size 0/1**

**Table 13-26. SDMA Task Size 0/1 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| | srcSize[1:0] | Each of the 16 tasks can be programmed to use the source and destination sizes contained in one of the Task Size Registers. The task size information is used by the SDMA module to determine the source and destination transfer size of the operands. When the size contained the task descriptor is set to 2'b11 then the size field from the Task Size Control register is selected.<br>srcSize[1:0]—source size<br>00 Word (32 bit)<br>01 Byte<br>10 Word<br>11 Word<br>destSize[1:0]—destination size<br>00 Word (32 bit)<br>01 Byte<br>10 Word<br>11 Word |

### 13.15.1.25.1 SDMA Task 0 and Task Size 1 Map

| Offset | Register Name | Byte 0 | Byte 1 | Byte 2 | Byte 3 | Access |
|---|---|---|---|---|---|---|
| 0x1260 | Task Size 0 | TS[0:1] | TS[2:3] | TS[4:5] | TS[5:7] | R/W |
| 0x1264 | Task Size 1 | TS[8:9] | TS[10:11] | TS[12:13] | TS[14:15] | R/W |

**Figure 13-26. SDMA Task Size Map**

See Figure 13-33 for details. Each task has 4 bits allocated (2 for source and 2 for destination size).

## 13.15.1.26 SDMA Reserved Register 1

Address MBAR + 0x1268

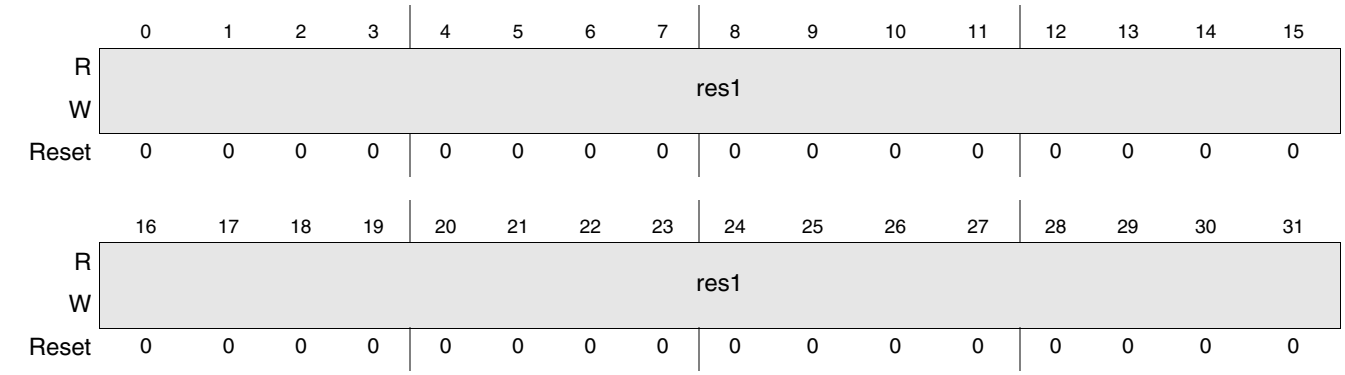



**Figure 13-27. SDMA Reserved Register 1**

**Table 13-27. SDMA Reserved Register 1 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:31 | res1 | Reserved |

## 13.15.1.27 SDMA Reserved Register 2

Address MBAR + 0x126C

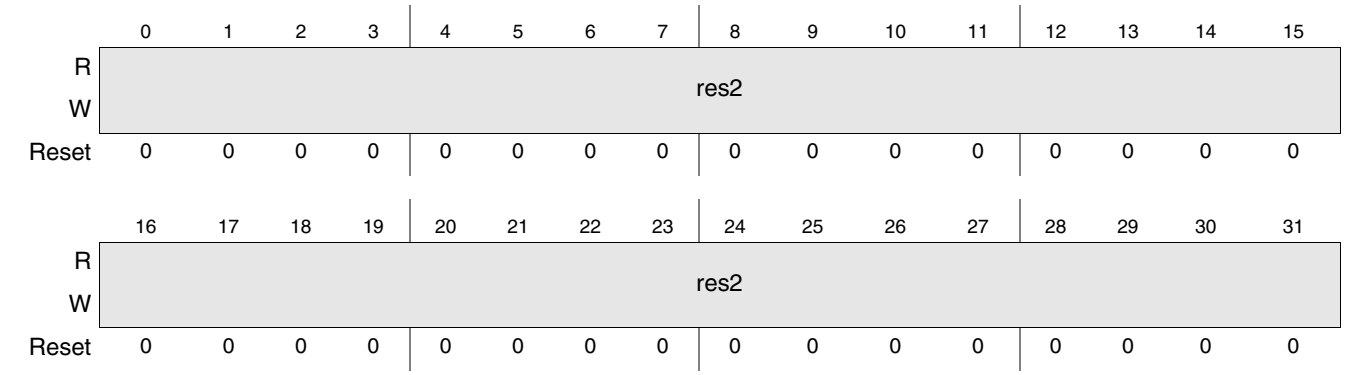



**Figure 13-28. SDMA Reserved Register 2**

**Table 13-28. SDMA Reserved Register 2 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:31 | res2 | Reserved |

## 13.15.1.28 SDMA Debug Module Comparator 1, Value1 Register

Address MBAR + 0x1270

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Value1 | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Value1 | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-29. SDMA Debug Module Comparator 1, Value1 Register**

**Table 13-29. SDMA Debug Module Comparator 1, Value1 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:31 | Value1 | Debug Module Comparator 1 Value. |

## 13.15.1.29 SDMA Debug Module Comparator 2, Value2 Register

Address MBAR + 0x1274

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Value2 | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Value2 | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-30. SDMA Debug Module Comparator 2, Value2 Register**

**Table 13-30. SDMA Debug Module Comparator 2, Value2 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:31 | Value2 | Debug Module Comparator 2 Value. |

## 13.15.1.30 SDMA Debug Module Control Register

Address MBAR + 0x1278

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Block Tasks | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | AA | B | Comparator Type 1 | | | Comparator Type 2 | | | and/ or | EU breakpoints | | | | E | I | B |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 13-31. SDMA Debug Module Control Register**

**Table 13-31. SDMA Debug Module Control Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:15 | Block Tasks | Specify for each of tasks 15-0, whether to block that task with detection of a breakpoint (bit 0 halts TASK 15, bit 1 halts TASK 14, etc)<br>0 Do not block task<br>1 Block the task |
| 16 | AA | AutoArm—specifies whether or not the triggered bit dbgStatusReg[16] will be automatically reset to 0 following the saving of context for a breakpoint. This bit is set to 0 at reset.<br>0 Triggered bit will not be automatically reset<br>1 Triggered bit will be automatically reset |
| 17 | B | Breakpoint—This bit specifies whether or not to take a breakpoint. This bit is set to 0 at reset.<br>0 Disable breakpoints<br>1 Enable breakpoints |
| 18:20 | Comparator Type 1 | Comparator 1 type—These bits specify the type of data that has been loaded into comparator 1; refer to Table 13-32 for the bit encoding. |
| 21:23 | Comparator Type 2 | Comparator 2 type—These bits specify the type of data that has been loaded into comparator 2; refer to Table 13-33 for the bit encoding. |
| 24 | and / or | AND/OR—This specifies what type of operation is to be used with the comparators. This bit is set to 0 at reset.<br>0 Indicates an OR'ing of the comparators<br>1 Indicates an AND'ing of the comparators |
| 25:28 | EU breakpoints | euBreakpoint: These bits indicate that a breakpoint has occurred in one of the four execution units. Each execution unit has one bit dedicated to it. A 1 in any of these bits indicates that the associated execution unit has issued breakpoint. These bits are sticky and must be overwritten to continue. These bits are cleared to zero at reset. See Table 13-35 for the bit encoding.<br>MPC5200B has integrated only EU3 |
| 29 | E | Enable External Breakpoint.<br>0 Do not enable external breakpoint to cause a halt condition<br>1 Allow external breakpoint to cause a halt condition |

**Table 13-31. SDMA Debug Module Control Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 30 | I | Enable Internal Breakpoint<br>0 Do not enable internal breakpoint to cause a halt condition<br>1 Allow internal breakpoint to cause a halt condition |
| 31 | EB | Enable Breakpoint (this bit must be always set to allow any kind of breakpoint to halt the task)<br>0 Disable breakpoint<br>1 Enable breakpoint |

**Table 13-32. Comparator 1 Type Bit Encoding**

| Encoding | Comparator Type 1 |
|---|---|
| 000 | uninitialized |
| 001 | write address |
| 010 | read address |
| 011 | current pointer |
| 100 | task # |
| 101 | reserved |
| 110 | reserved |
| 111 | reserved |

**Table 13-33. Comparator 2 Type Bit Encoding**

| Encoding | Comparator Type 2 |
|---|---|
| 000 | uninitialized |
| 001 | write address |
| 010 | read address |
| 011 | current pointer |
| 100 | task # |
| 101 | counter value |
| 110 | reserved |
| 111 | reserved |

## NOTE

The reserved encodings are set to 0 indicating an uninitialized state.

**Table 13-34. EU Breakpoint Encoding**

| | EU3 | EU2 | EU1 | EU0 |
|---|---|---|---|---|
| Reset | 0 | 0 | 0 | 0 |

It must be noted that even if a breakpoint is issued at a specific address the SDMA engine will halt ONLY at a “data aligned” boundary (for instance, if the task moves 32 bits of data per transaction and a breakpoint is set at address 0x02 then the task will be halted at offset 0x04).

## 13.15.1.31 SDMA Debug Module Status Register

Address MBAR + 0x127C

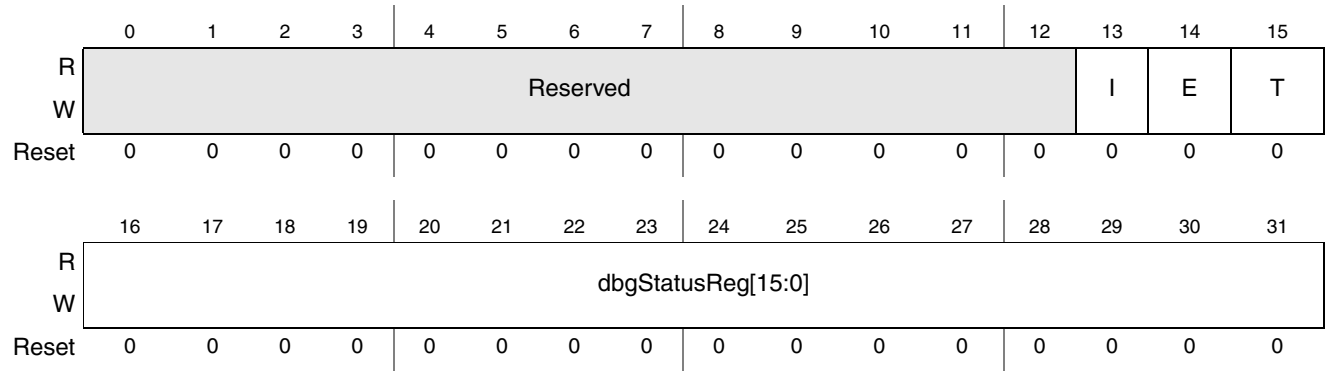



**Figure 13-32. SDMA Debug Module Status Register**

**Table 13-35. SDMA Debug Module Status Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:12 | Reserved | Reserved |
| 13 | I | Interrupt—This bit indicates whether or not an interrupt has been taken. This bit is set to 0 at reset. It can be written by the user or the SDMA engine.<br>0 No Interrupt<br>1 Interrupt taken |
| 14 | E | External Breakpoint—This bit indicates detection of an external breakpoint. Status bit is sticky and requires a one (1) to be written to it to clear it. The writing of a zero (0) to this bit has no effect. This bit is set to zero (0) at reset.<br>0 No external breakpoint detected<br>1 External breakpoint detected |
| 15 | T | Triggered (dbgStatusReg[16])—This bit indicates that a SmartDMA breakpoint has occurred with the current settings. Status bit is sticky and requires a one (1) to be written to it to clear it. The writing of a zero (0) to this bit has no effect. This bit is set to zero (0) at reset.<br>0 Armed or normal operation<br>1 Triggered or debug mode |
| 16:31 | dbgStatusReg[15:0] | dbgTaskBlock (dbgStatusReg[15:0])—Each bit corresponds to one of the 16 task numbers. The value of the register bit reflects the debug state of the task number. A bit is cleared by writing a one to that bit location; writing a zero (0) has no effect. At system reset, all bits are initialized to logic zeros (0).<br>0 Unblocked or normal operation<br>1 Blocked, task has been blocked due to a breakpoint |

## 13.16 On-Chip SRAM

MPC5200B contains 16KBytes of on-chip SRAM. This memory is directly accessible by the BestComm DMA unit. It is used primarily as storage for task table and buffer descriptors used by BestComm DMA to move peripheral data to and from SDRAM or other locations. These descriptors must be downloaded to the SRAM at boot.

This SRAM resides in the MPC5200B internal register space and is also accessible by the processor core. As such it can be used for other purposes, such as scratch pad storage. The 16kBytes SRAM starts at location MBAR + 0x8000.

## 13.17 Programming Model

The SDMA engine expects the programmer to initialize several things in memory including the Task Table and the Variable Table(s). These are described and illustrated in the following sub-sections. The various descriptors used in each task are also described below.

### 13.17.1 Task Table

The programmer must initialize the *taskBAR register* in the IPB Interface Module (offset 0x1200). The Task Table (sometime also referred to as Entry Table), whose format is shown in Figure 13-33, should reside at the address specified by *taskBAR*.

The Task Table base address must be aligned to a 512-byte boundary. There are sixteen tasks, each of which has its own unique Task Descriptor Table (TDT) start pointer, TDT end pointer, Variable Table pointer, control information, and status information. The TDT start pointer is a 32-bit value that points to the first descriptor, an LCD, of that particular task. The remaining descriptors (LCDs and DRDs) should consecutively follow the first one in memory, except in special branching cases. The TDT end pointer is a 32-bit value that points to the last descriptor, which must be a DRD, of that particular task.

The 32-bit Variable Table pointer points to the top of the 32-word (128 byte) memory space where this task's Variable Table resides. The Variable Table format is explained later in more detail.

The control information is located in the fourth word of each task's Task Table information as shown in Figure 13-33. Bits 0 through 23 contain the base address for this task's function descriptors. Control bits 24 through 31 are for precise increment, not resetting the error code, whether to pack data, integer mode, complex data mode, to enable speculative reads and whether bursting is allowed on reads and writes.

The fifth and sixth word of the task table are reserved.

The seventh word is a pointer to the Context Save Area where important data is saved and later restored in case of a task switch.

The last word is used by the SDMA engine in conjunction with Literal Initialization of LCD (to save variable usage). The user should not modify the values stored there.

| | 0 | 4 5 | 14 15 | 19 20 | 31 |
|---|---|---|---|---|---|
| **Task 0** | Task Descriptor Start Pointer | | | | |
| | Task Descriptor End Pointer | | | | |
| | Variable Table Pointer | | | | |
| | Function Descriptor Base Address | | | RSV PI E P I SPR CW RL | |
| | Reserved | | | | |
| | Reserved | | | | |
| | Base Address for Context Save Space | | | | |
| | Literal Base 0 | Reserved | Literal Base 1 | Reserved | |
| ..... | | | | | |
| **Task n** | Task Descriptor Start Pointer | | | | |
| | Task Descriptor End Pointer | | | | |
| | Variable Table Pointer | | | | |
| | Function Descriptor Base Address | | | RSV PI E P I SPR CW RL | |
| | Reserved | | | | |
| | Reserved | | | | |
| | Base Address for Context Save Space | | | | |
| | Literal Base 0 | Reserved | Literal Base 1 | Reserved | |

**Note:** For each task, the start pointer, end pointer, and variable table pointer are 32-bit values. For the task control bits, bits 0 through 23 are for the Function Descriptor Base Address, and bits 24 through 31 are:

RSV = Reserved,
PI = Precise Increment,
E = do not reset error code if ‘1’
P = Pack data if ‘1’
I = Integer mode if ‘1’ (else fractional)
SPR = speculative enable
CW = Combined Write Enable if ‘1’
RL = Read Line Buffer Enable if ‘1’ speculative Reads if ‘1’

**Figure 13-33. Task Table**

**Table 13-36. Behavior of Task Table Control Bits**

| Control Function | Value | Meaning |
|---|---|---|
| Precise Increment | 0 | Increments are allowed at any time the SDMA can do it |
| | 1 | Only increment at the end of an iteration |
| No Error Code Reset | 0 | Reserved |
| | 1 | Reserved |
| Pack | 0 | Do not pack data |
| | 1 | Pack data |
| Integer Mode | 0 | Fractional data representation |
| | 1 | Integer data representation |
| Speculative Reads | 0 | Disabled |
| | 1 | Enabled |
| Combined Write Enable | 0 | Do not enable combined writes |
| | 1 | Enable combined writes |
| Read Line Buffer Enable | 0 | Do not enable line reads |
| | 1 | Enable line reads |

#### 13.17.1.1 Integer Mode

This input signal is only valid if the pack signal is negated (set to ‘0’). This signal indicates if the SDMA engine should operate in integer mode or fractional mode. During integer mode, the engine sign-extends read data and the it reads the write size amount of data starting from the MSB position and drives it to the proper destination byte lanes as indicated by the write address.

During fractional mode, the engine zero-extends read data and the ADS reads the write size amount of data starting from the LSB position and drives it to the proper write byte lanes as indicated by the write address.

#### 13.17.1.2 Pack

This input signal indicates that packing or unpacking of data should occur if the read size does not equal the write size. The pack signal has precedence over the integerMode signal.

This signal indicates to the SmartDMA that it should pack data when the source size does not match the destination size. When this signal is asserted, the SmartDMA should pack data, and the *integerMode* signal is ignored. Otherwise, the SmartDMA should not pack data. Packing data refers to the case where the SmartDMA will wait for a full word of data before passing the data to one of the memory interfaces.

### 13.17.2 Variable Table

Table 13-37 shows the Variable Table format to which each task must adhere. The Variable Table pointer that is located in the Task Table in Figure 13-33 points to the first location in this 32-word (128-byte) memory space.

If restoring, and the Variable Table has been modified, then the new Variable Table pointer is located at the end of the context save space for the corresponding task. The Variable Table for each task must be aligned

to a 16-byte boundary (to aid in address calculation). Before executing a particular task, that task's Variable Table must be initialized with the appropriate data. Specifically, any constants, initial values, and increment values must be written to the Variable Table before executing the corresponding task.

Variables may be loaded into words 0 through 23.Increment values 0 through 7 may be loaded into words 24 through 31, respectively.

Any of the eight increment values may be used as normal Loop-Index Variables or Constants if they are not needed as increment values. All of these variables and increment values may be used to initialize loop-index registers. However, only variables 0 through 31 may be written by the ADS. At this time, if variables 24 through 31 are written, it is assumed that these variables should be treated as normal Loop-Index Variables or Constants and not as increment values. Also, note that Variable Tables may overlap if sharing the last eight variables with another task's Variable Table is desired. In addition, if a task does not use the last 16 variables, another Variable Table could start immediately after that task's increment values, so as to not waste memory.

**Table 13-37. Variable Table per Task**

| # | Hex Offset | Contents | Comments |
|---|---|---|---|
| 0 | 00 | Loop-Index Variable or Constant 0 | These twenty-four words (32 bits) are used for constant operands to the EUs, for initialization values, or for a place to write results straight to a variable in this table. These are typically preloaded by the CPU unless you are writing directly to a variable. |
| 1 | 04 | Loop-Index Variable or Constant 1 | |
| 2 | 08 | Loop-Index Variable or Constant 2 | |
| 3 | 0c | Loop-Index Variable or Constant 3 | |
| 4 | 10 | Loop-Index Variable or Constant 4 | |
| 5 | 14 | Loop-Index Variable or Constant 5 | |
| 6 | 18 | Loop-Index Variable or Constant 6 | |
| 7 | 1c | Loop-Index Variable or Constant 7 | |
| 8 | 20 | Loop-Index Variable or Constant 8 | |
| 9 | 24 | Loop-Index Variable or Constant 9 | |
| 10 | 28 | Loop-Index Variable or Constant 10 | |
| 11 | 2c | Loop-Index Variable or Constant 11 | |
| 12 | 30 | Loop-Index Variable or Constant 12 | |
| 13 | 34 | Loop-Index Variable or Constant 13 | |
| 14 | 38 | Loop-Index Variable or Constant 14 | |
| 15 | 3c | Loop-Index Variable or Constant 15 | |
| 16 | 40 | Loop-Index Variable or Constant 16 | |
| 17 | 44 | Loop-Index Variable or Constant 17 | |
| 18 | 48 | Loop-Index Variable or Constant 18 | |
| 19 | 4c | Loop-Index Variable or Constant 19 | |
| 20 | 50 | Loop-Index Variable or Constant 20 | |
| 21 | 54 | Loop-Index Variable or Constant 21 | |
| 22 | 58 | Loop-Index Variable or Constant 22 | |
| 23 | 5c | Loop-Index Variable or Constant 23 | |

**Table 13-37. Variable Table per Task (continued)**

| # | Hex Offset | Contents | Comments |
|---|---|---|---|
| 24 | 60 | Compare Type[31:29], Reserved[28:16], Increment Variable 0[15:0] | Variables 24–31 may be increment variables of the format shown to the left. Any of these variables may be used as normal Loop-Index Variables or Constants (like variables 0–23) instead. |
| 25 | 64 | Compare Type[31:29], Reserved[28:16], Increment Variable 1[15:0] | |
| 26 | 68 | Compare Type[31:29], Reserved[28:16], Increment Variable 2[15:0] | |
| 27 | 6c | Compare Type[31:29], Reserved[28:16], Increment Variable 3[15:0] | |
| 28 | 70 | Compare Type[31:29], Reserved[28:16], Increment Variable 4[15:0] | |
| 29 | 74 | Compare Type[31:29], Reserved[28:16], Increment Variable 5[15:0] | |
| 30 | 78 | Compare Type[31:29], Reserved[28:16], Increment Variable 6[15:0] | |
| 31 | 7c | Compare Type[31:29], Reserved[28:16], Increment Variable 7[15:0] | |

When the user writes a program, or when the assembler converts the user's programs, the SDMA engine will use the initialization variables and constants that the user or processor should have loaded into the Variable Table. The initial index variables in the LCD tells the engine to allocate space for the resulting variables in the loop registers. The space will be allocated consecutively, so the user knows with which register each variable will be associated. This is important when the user's program tries to reference one of these previously allocated variables. Also, the eight increment variables in positions 24 through 31 of Table 13-37 are preloaded by the processor, as programmed by the user.

# Chapter 14
# Fast Ethernet Controller (FEC)

## 14.1 Overview

The fast Ethernet controller (FEC) is an Ethernet MAC plus two 1 Kbyte FIFOs that work under the control of the processor and BestComm DMA engine to support 10/100 Mbps Ethernet/802.3 networks. Figure 14-1 shows a block diagram.

A brief introduction and overview of the major functional blocks aid in understanding and programming the FEC.

The FEC is controlled by writing through the system interface (SIF) module into control registers located in each block. The control/status register (CSR) block provides global control and interrupt handling registers. User programming of the CSR is the primary focus of this chapter.

The RISC based Ethernet controller provides the following functions:

- Initialization
- Address recognition for receive frames
- Random number generation for transmit collision backoff timer

The FIFO controller is the focal point of all data flow in the FEC. The FIFO is divided into a transmit and receive FIFO of 1Kbyte each. Transmit data flows from the CommBus into the transmit FIFO and through the transmit block to the physical layer device (PHY). Receive data flows from the PHY to the receive block and is pulled out of the FIFO by BestComm. BestComm data transfers are interrupt driven. Interrupt driven data movement from the processor is not supported.

The bus controller decides which block is to be the T-bus master for each cycle. All the blocks receive their control information over the T-bus and provide status information over this same internal bus.

The media independent interface (MII) block provides a serial channel for control/status communication with the external physical layer device (transceiver or PHY). The serial channel consists of the MDC (clock) and MDIO (bidirectional data I/O) lines of the MII interface.

The transmit and receive blocks provide the Ethernet MAC functionality (with some assistance from the BestComm unit). Internal to these blocks are clock domain boundaries between the system clock and the network clocks supplied by the PHY.

The management information base (MIB) block maintains the counters for a variety of network events and statistics. The counters support the RMON (RFC 1757) Ethernet statistics group and some of the IEEE 802.3 counters.

The FEC supports several standard MAC-PHY interfaces to connect to an external Ethernet transceiver. One is the 10/100 Mbps MII (18-wire) interface. Another is the 10-Mbps only 7-Wire interface, which uses a subset of the MII pins.

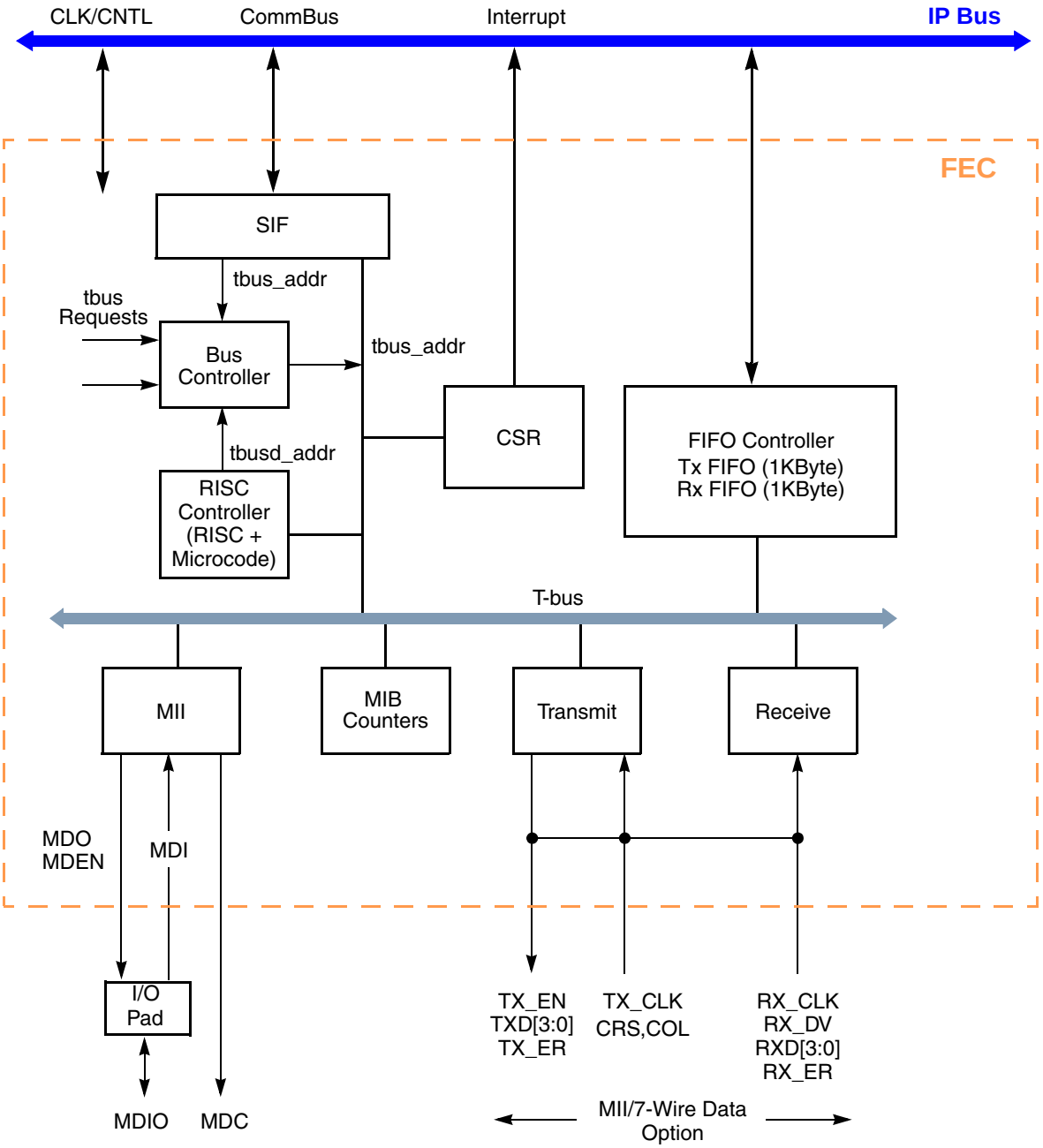



**Figure 14-1. Block Diagram—FEC**

### 14.1.1 Features

The FEC incorporates several features/design goals that are key to its use:

- Support for different Ethernet physical interfaces:
  - 100 Mbps IEEE 802.3 MII
  - 10 Mbps IEEE 802.3 MII
  - 10 Mbps 7-wire interface (industry standard)
- IEEE 802.3 full-duplex flow control
- Programmable max frame length supports IEEE 802.1 VLAN tags and priority
- Support for full-duplex operation (200 Mbps throughput) with a minimum system clock rate of 50 MHz.
- Support for half-duplex operation (100 Mbps throughput) with a minimum system clock rate of 25 MHz.
- Large (1 Kbyte) on-chip transmit and receive FIFOs to support a variety of bus latencies.
- Retransmission from transmit FIFO following a collision (no processor bus utilization).
- Automatic internal flushing of the Rx FIFO for runts (collision fragments) and address recognition rejects (no processor bus utilization).
- Address recognition
  - Frames with broadcast address may be always accepted or always rejected
  - Exact match for single 48-bit individual (unicast) address
  - Hash (64-bit hash) check of individual (unicast) addresses
  - Hash (64-bit hash) check of group (multicast) addresses
  - Promiscuous mode

## 14.2 Modes of Operation

The primary operational modes are described in this section.

### 14.2.1 Full- and Half-Duplex Operation

This is determined by the X_CNTRL register FDEN bit. Full-duplex mode is intended for use on point to point links between switches or end node to switch. Half-duplex mode is used in connections between an end node and a repeater or between repeaters.

Full-duplex flow control is an option that may be enabled in full-duplex mode.

### 14.2.2 10 Mbps and 100 Mbps MII Interface Operation

The MAC-PHY interface operates in MII mode by asserting the R_CNTRL register MII_MODE bit. MII is the media independent interface defined by the 802.3 standard for 10/100 Mbps operation.

Speed of operation is determined by the TX_CLK and RX_CLK pins, which are driven by the transceiver. The transceiver either auto-negotiates the speed or it may be controlled by software using the serial management interface (MDC/MDIO pins) to the transceiver.

### 14.2.3 10Mbps 7-Wire Interface Operation

If the external transceiver supports 10 Mbps only and uses a 7-wire style interface then deassert the R_CNTRL register MII_MODE bit in the R_CNTRL register. This style of interface is not defined by the 802.3 standard, but instead is an industry standard.

### 14.2.4 Address Recognition Options

The options supported are promiscuous, broadcast reject, individual address hash or exact match and multicast hash match. Refer to the R_CNTRL register for address recognition programming.

### 14.2.5 Internal Loopback

Internal loopback mode is selected using the R_CNTRL register LOOP bit.

## 14.3 I/O Signal Overview

This section defines the FEC-to-chip pin I/O. The FEC network interface supports multiple options. One is the MII option that requires 18 I/O pins and supports both data and an out-of-band serial management interface to the PHY (transceiver) device. The MII option supports both 10 and 100 Mbps Ethernet rates. The second is referred to as the 7-wire interface and supports only 10 Mbps Ethernet data. The 7-wire interface uses a subset of the MII signals.

Table 14-1 shows the network interface signals and lists 18 signals, all of which are used for the 10/100 MII interface.

**NOTE**

The MDIO pin is bidirectional and corresponds to the FEC block MDI, MDO and MDIO pins. The 7-wire interface option uses a subset of these signals.

**Table 14-1. Signal Properties**

| Signal Name | Chip Pin | Function | Reset State |
|---|---|---|---|
| tx_en | ETH0 | MII—transmit data valid output<br>7-wire—transmit data valid output | 0 |
| tdata[0] | ETH1 | MII—transmit data bit 0 output<br>7-wire—transmit data output | — |
| tdata[1] | ETH2 | MII—transmit data bit 1 output | — |
| tdata[2] | ETH3 | MII—transmit data bit 2 output | — |
| tdata[3] | ETH4 | MII—transmit data bit 3 output | — |
| tx_er | ETH5 | MII—transmit error output | 0 |
| mdc | ETH6 | MII—management clock output | 0 |
| mdi<br>mdo<br>md_en | ETH7 | MII—management data bidirect | Hi-Z (input) |

**Table 14-1. Signal Properties (continued)**

| Signal Name | Chip Pin | Function | Reset State |
|---|---|---|---|
| rx_dv | ETH8 | MII—Rx data valid input<br>7-wire—rena input | — |
| rx_clk | ETH9 | MII—Rx clock input<br>7-wire—Rx clock input | — |
| col | ETH10 | MII—collision input<br>10 Mbps 7-wire—collision input | — |
| tx_clk | ETH11 | MII—transmit clock input<br>7-wire—transmit clock input | — |
| rdata[0] | ETH12 | MII—Rx data bit 0 input<br>7-wire—Rx data input | — |
| rdata[1] | ETH13 | MII—Rx data bit 1 input | — |
| rdata[2] | ETH14 | MII—Rx data bit 2 input | — |
| rdata[3] | ETH15 | MII—Rx data bit 3 input | — |
| rx_er | ETH16 | MII—Rx error input | — |
| crs | ETH17 | MII—carrier sense input | — |

## 14.3.1 Detailed Signal Descriptions

### 14.3.1.1 MII Ethernet MAC-PHY Interface

This section gives a detailed description of the Media-Independent Interface (MII). An overview of the MII is presented followed by a description of the MII signals. Two different types of MII frames are described. A brief MII management function overview is given.

The MII interface has 18 signals. Tx and Rx functions require 7 signals each:

- 4 data signals
- 1 delimiter
- 1 error
- 1 clock

Media status is indicated by 2 signals:

- 1 signal indicates a carrier is present.
- 1 signal indicates a collision occurred.

Management interface is provided by 2 signals.

MII signals are described below.

**Tx_CLK** A continuous clock that provides a timing reference for Tx_EN, TxD, and Tx_ER. The frequency of Tx_CLK is 25% of the transmit data rate, ± 100 ppm. Duty cycle shall be 35%-65% inclusive.

**Rx_CLK** A continuous clock that provides a timing reference for Rx_DV, RxD, and Rx_ER. The frequency of Rx_CLK is 25% of the receive data rate, with a duty cycle between 35% and 65%.

**Tx_EN** Assertion of this signal indicates valid nibbles are being presented on the MII. This signal is asserted with the first nibble of preamble and is negated prior to the first Tx_CLK following the final nibble of the frame.

**TxD** TxD[0:3] represent a nibble of data when Tx_EN is asserted and have no meaning when Tx_EN is de-asserted. Table 14-2 summarizes the permissible encoding of TxD.

**Tx_ER** Assertion of this signal for one or more clock cycles while Tx_EN is asserted causes PHY to transmit one or more illegal symbols. Asserting Tx_ER has no affect when operating at 10 Mbps or when Tx_EN is de-asserted This signal transitions synchronously with respect to Tx_CLK.

**Rx_DV** When this signal is asserted, PHY is indicating a valid nibble is present on the MII. This signal remains asserted from the first recovered nibble of the frame through the last nibble. Assertion of Rx_DV must start no later than the SFD, and exclude any EOF.

**RxD** RxD[0:3] represents a nibble of data to be transferred from the PHY to the MAC when Rx_DV is asserted. A completely formed SFD must be passed across the MII. When Rx_DV is not asserted, RxD has no meaning. There is an exception to this which is explained later. Table 14-3 summarizes the permissible encoding of RxD.

**Rx_ER** When Rx_ER and Rx_DV are asserted, the PHY has detected an error in the current frame. When Rx_DV is not asserted, Rx_ER shall have no affect. This signal transitions synchronously with Rx_CLK.

**CRS** Signal is asserted when Tx or Rx medium is not idle. If a collision occurs, CRS remains asserted through the duration of the collision. This signal is not required to transition synchronously with Tx_CLK or Rx_CLK.

**COL** Signal is asserted on a collision detection and remains asserted while the collision persists. The signal behavior is not specified when in full-duplex mode. This signal is not required to transition synchronously with Tx_CLK or Rx_CLK.

**MDC** Signal provides a timing reference to the PHY for data transfers on the MDIO signal. MDC is aperiodic and has no maximum high or low times. The minimum high and low times is 160 ns with the minimum period being 400 ns.

**MDIO** Signal transfers control/status information between the PHY and MAC. It transitions synchronously to MDC. The MDIO pin is a bidirectional pin. The internal FEC signals that connect to this pad are: MDI (data in), MDO (data out), and MD_EN (direction control, high for output).

Table 14-2 lists the interpretation of possible encodings for Tx_EN and Tx_ER.

**Table 14-2. MII: Valid Encoding of TxD, Tx_EN and Tx_ER**

| TX_EN | TX_ER | TXD | Indication |
|---|---|---|---|
| 0 | 0 | 0000 through 1111 | Normal inter-frame |
| 0 | 1 | 0000 through 1111 | Reserved |
| 1 | 0 | 0000 through 1111 | Normal data transmission |
| 1 | 1 | 0000 through 1111 | Transmit error propagation |

A false carrier condition occurs if the PHY detects a bad start-of-stream delimiter. This condition signals the MII by asserting Rx_ER and placing 1110 on RxD. Rx_DV must also be de-asserted. Valid Rx_DV, Rx_ER and RxD[3:0] encodings are shown in Table 14-3.

**Table 14-3. MII: Valid Encoding of RxD, Rx_ER and Rx_DV**

| RX_DV | RX_ER | RXD | Indication |
|---|---|---|---|
| 0 | 0 | 0000 through 1111 | Normal inter-frame |
| 0 | 1 | 0000 | Normal inter-frame |
| 0 | 1 | 0001 through 1101 | Reserved |
| 0 | 1 | 1110 | False Carrier |
| 0 | 1 | 1111 | Reserved |
| 1 | 0 | 0000 through 1111 | Normal data reception |
| 1 | 1 | 0000 through 1111 | Data reception with errors |

### 14.3.1.2 MII Management Frame Structure

A transceiver management frame transmitted on the MII management interface uses the MDIO and MDC pins. A transaction or frame on this serial interface has the following format:

<preamble><st><op><phyad><regad><ta><data><idle>

**Table 14-4. MMI Format Definitions**

| Name | Description |
|---|---|
| <preamble> | Optional—consists of a sequence of 32 continuous logic 1s. |
| <st> | Start of frame—indicated by a <01> pattern. |
| <op> | Operation code:<br>Read instruction is <10><br>Write instruction is <01> |
| <phyad> | A 5-bit field that lists up to 32 PHYs be addressed. The first address bit transmitted is the msb of the address. |
| <regad> | A 5-bit field that lets 32 registers be addressed within each PHY. The first register bit transmitted is the msb of the address. |
| <ta> | A 2-bit field that provides spacing between the register address field and the data field to avoid contention on the MDIO signal during a read operation. |
| <data> | Data field is 16 bits wide. Data bit 15 is first bit transmitted and received. |
| <idle> | During idle condition, MDIO is in the high impedance state. |

#### 14.3.1.2.1 MII Management Register Set

The MII management register set located in the PHY may consist of a basic register set and an extended register set as defined in Table 14-5.

**Table 14-5. MII Management Register Set**

| Register Address | Register Name | Basic/Extended |
|---|---|---|
| 0 | Control | B |
| 1 | Status | B |
| 2:3 | PHY Identifier | E |
| 4 | Auto-Negotiation Advertisement | E |
| 5 | AN Link Partner Ability | E |
| 6 | AN Expansion | E |
| 7 | AN Next Page Transmit | E |
| 8:15 | Reserved | E |
| 16:31 | Vendor Specific | E |

## 14.4 FEC Memory Map and Registers

The FEC device is programmed by a combination of control/status registers (CSRs) and BestComm task loops. Since the FEC software model is BestComm-based, there is no similarity with existing CPM-based products' coding.

The CSRs are used for mode control, interrupts and extraction of status information. BestComm tasks are used to pass data buffers and related buffer or frame information between the hardware and software.

All access via microprocessor to and from the registers must be 32-bit accesses. There is no support for accesses other than 32-bit. All access via BestComm to and from the registers may be byte, word or longword (32-bit) accesses. Top Level Module Memory Map

The FEC implementation requires a 2KByte memory map space. This is divided into two sections of 512 Bytes and an additional 1KBytes of reserved space. The first 512 Bytes is used for Control and Status Registers. The second contains event/statistic counters held in the MIB block. Table 14-6 defines the top level memory map.

**Table 14-6. Module Memory Map**

| Address | Function |
|---|---|
| 000–1FF | Control/Status Registers |
| 200–3FF | MIB Block Counters, see Table 14-8 |
| 400–7FF | Reserved |

### 14.4.1 Control and Status (CSR) Memory Map

**Table 14-7. CSR Counters**

| Address | Mnemonic | Name |
|---|---|---|
| 000 | FEC_ID | FEC_ID Register |
| 004 | IEVENT | Interrupt Event Register |
| 008 | IMASK | Interrupt Enable Register |
| 00C | | Reserved |
| 010 | R_DES_ACTIVE | Receive Ring Updated Flag |
| 014 | X_DES_ACTIVE | Transmit Ring Updated Flag |
| 018-020 | | Reserved |
| 024 | ECNTRL | Ethernet Control Register |
| 028-03C | | Reserved |
| 040 | MII_DATA | MII Data Register |
| 044 | MII_SPEED | MII Speed Register |
| 04C-060 | | Reserved |
| 064 | MIB_CONTROL | MIB Control/Status Register |
| 068-080 | | Reserved |
| 084 | R_CNTRL | Receive Control Register |
| 088 | R_HASH | Receive Hash |
| 08C-0C0 | | Reserved |
| 0C4 | X_CNTRL | Transmit Control Register |
| 0C8-0E0 | | Reserved |
| 0E4 | PADDR1 | Physical Address Low |
| 0E8 | PADDR2 | Physical Address High+ Type Field |
| 0EC | OP_PAUSE | Opcode + Pause Duration |
| 0F0-114 | | Reserved |
| 118 | IADDR1 | Upper 32 bits of individual Hash Table |
| 11C | IADDR2 | Lower 32 bits of individual Hash Table |
| 120 | GADDR1 | Upper 32 bits of Group Hash Table |
| 124 | GADDR2 | Lower 32 bits of Group Hash Table |
| 128-140 | | Reserved |
| 144 | X_WMRK | Transmit FIFO Watermark |
| 148-180 | | Reserved |
| 184 | RFIFO_DATA | Receive FIFO Data |
| 188 | RFIFO_STATUS | Receive FIFO Status |
| 18C | RFIFO_CONTROL | Receive FIFO Control |

**Table 14-7. CSR Counters (continued)**

| Address | Mnemonic | Name |
|---|---|---|
| 190 | RFIFO_LRF_PTR | Receive FIFO Last Read Frame Pointer |
| 194 | RFIFO_LWF_PTR | Receive FIFO Last Write Frame Pointer |
| 198 | RFIFO_ALARM | Receive FIFO Alarm Pointer |
| 19C | RFIFO_RDPTR | Receive FIFO Read Pointer |
| 1A0 | RFIFO_WRPTR | Receive FIFO Write Pointer |
| 1A4 | TFIFO_DATA | Transmit FIFO Data |
| 1A8 | TFIFO_STATUS | Transmit FIFO Status |
| 1AC | TFIFO_CONTROL | Transmit FIFO Control |
| 1B0 | TFIFO_LRF_PTR | Transmit FIFO Last Read Frame Pointer |
| 1B4 | TFIFO_LWF_PTR | Transmit FIFO Last Write Frame Pointer |
| 1B8 | TFIFO_ALARM | Transmit FIFO Alarm Pointer |
| 1BC | TFIFO_RDPTR | Transmit FIFO Read Pointer |
| 1C0 | TFIFO_WRPTR | Transmit FIFO Write Pointer |
| 1C4 | RESET_CNTRL | Reset Control |
| 1C8 | XMIT_FSM | Transmit FSM |
| 1CC-1FF | | |

## 14.4.2 MIB Block Counters Memory Map

Table 14-8 defines the MIB Counters memory map which defines the MIB RAM space locations where hardware-maintained counters reside. These fall in the 3200-33FF address range. Counters are divided into two groups.

1. **RMON counters**—are included which cover Ethernet statistics counters defined in RFC 1757. In addition to Ethernet statistics group counters, a counter is included to count truncated frames as FEC only supports frame lengths up to 2047bytes. RMON counters are implemented independently for Tx and Rx, to ensure accurate network statistics when operating in full-duplex mode.
2. **IEEE counters**—are included which support the mandatory and recommended counter packages defined in Section 5 of ANSI/IEEE Standard 802.3 (1998 edition). FEC supports IEEE Basic Package objects, but does not require MIB block counters. In addition, some recommended package objects supported do not require MIB counters. Counters for Tx and Rx full-duplex flow control frames are included.

**Table 14-8. MIB Counters**

| Address | Mnemonic | Description |
|---|---|---|
| 200 | RMON_T_DROP | Count of Frames Not Correctly Counted |
| 204 | RMON_T_PACKETS | RMON Tx Packet Count |
| 208 | RMON_T_BC_PKT | RMON Tx Broadcast Packets |
| 20C | RMON_T_MC_PKT | RMON Tx Multicast Packets |
| 210 | RMON_T_CRC_ALIGN | RMON Tx Packets with CRC/Align error |
| 214 | RMON_T_UNDERSIZE | RMON Tx Packets less than 64 bytes, good CRC |
| 218 | RMON_T_OVERSIZE | RMON Tx Packets greater than MAX_FL bytes, good CRC |
| 21C | RMON_T_FRAG | RMON Tx Packets less than 64 bytes, bad CRC |
| 220 | RMON_T_JAB | RMONTxPackets greater than MAX_FL bytes, bad CRC |
| 224 | RMON_T_COL | RMON Tx collision count |
| 228 | RMON_T_P64 | RMON Tx 64 Byte packets |
| 22C | RMON_T_P65TO127 | RMON Tx 65 to 127 Byte packets |
| 230 | RMON_T_P128TO255 | RMON Tx 128 to 255 Byte packets |
| 234 | RMON_T_P256TO511 | RMON Tx 256 to 511 Byte packets |
| 238 | RMON_T_P512TO1023 | RMON Tx 512 to 1023 Byte packets |
| 23C | RMON_T_P1024TO2047 | RMON Tx 1024 to 2047 Byte packets |
| 240 | RMON_T_P_GTE2048 | RMON Tx packets with greater than 2048 Bytes |
| 244 | RMON_T_OCTETS | RMON Tx Octets |
| 248 | IEEE_T_DROP | Count of Frames Not Counted Correctly |
| 24C | IEEE_T_FRAME_OK | Frames Transmitted OK |
| 250 | IEEE_T_1COL | Frames Transmitted with Single Collision |
| 254 | IEEE_T_MCOL | Frames Transmitted with Multiple Collisions |
| 258 | IEEE_T_DEF | Frames Transmitted after Deferral Delay |
| 25c | IEEE_T_LCOL | Frames Transmitted with Late Collision |
| 260 | IEEE_T_EXCOL | Frames Transmitted with Excessive Collisions |
| 264 | IEEE_T_MACERR | Frames Transmitted with Tx FIFO Underrun |
| 268 | IEEE_T_CSERR | Frames Transmitted with Carrier Sense Error |
| 26C | IEEE_T_SQE | Frames Transmitted with SQE Error |
| 270 | T_FDXFC | Flow Control Pause Frames Transmitted |
| 274 | IEEE_T_OCTETS_OK | Octet Count for Frames Transmitted w/o Error |
| 278–27C | rsvd | Reserved |
| 280 | RMON_R_DROP | Count of frames Not Counted Correctly |
| 284 | RMON_R_PACKETS | RMON Rx Packet Count |
| 288 | RMON_R_BC_PKT | RMON Rx Broadcast Packets |
| 28C | RMON_R_MC_PKT | RMON Rx Multicast Packets |

**Table 14-8. MIB Counters (continued)**

| Address | Mnemonic | Description |
|---|---|---|
| 290 | RMON_R_CRC_ALIGN | RMON Rx Packets with CRC/Align error |
| 294 | RMON_R_UNDERSIZE | RMON Rx Packets less than 64 Bytes, good CRC |
| 298 | RMON_R_OVERSIZE | RMON Rx Packets greater than MAX_FL bytes, good CRC |
| 29C | RMON_R_FRAG | RMON Rx Packets less than 64 Bytes, bad CRC |
| 2A0 | RMON_R_JAB | RMONRxPackets greater than MAX_FL bytes, bad CRC |
| 2A4 | RMON_R_RESVD_0 | Reserved |
| 2A8 | RMON_R_P64 | RMON Rx 64 Byte packets |
| 2AC | RMON_R_P65TO127 | RMON Rx 65 to 127 Byte packets |
| 2B0 | RMON_R_P128TO255 | RMON Rx 128 to 255 Byte packets |
| 2B4 | RMON_R_P256TO511 | RMON Rx 256 to 511 Byte packets |
| 2B8 | RMON_R_P512TO1023 | RMON Rx 512 to 1023 Byte packets |
| 2BC | RMON_R_P1024TO2047 | RMON Rx 1024 to 2047 Byte packets |
| 2C0 | RMON_R_P_GTE2048 | RMON Rx packets with greater than 2048 Bytes |
| 2C4 | RMON_R_OCTETS | RMON Rx Octets |
| 2C8 | IEEE_R_DROP | Count of frames not counted correctly |
| 2CC | IEEE_R_FRAME_OK | Frames received OK |
| 2D0 | IEEE_R_CRC | Frames received with CRC error |
| 2D4 | IEEE_R_ALIGN | Frames received with alignment error |
| 2D8 | IEEE_R_MACERR | Rx FIFO overflow count |
| 2DC | R_FDXFC | Flow Control Pause frames received |
| 2E0 | IEEE_R_OCTETS_OK | Octet count for frames received without error |
| 2E4–2FC | rsvd | Reserved |
| 300–3FF | rsvd | Reserved |

### 14.4.3 FEC Registers

The FEC uses 37 32-bit registers. These registers are located at an offset from MBAR of 0x3000. Register addresses are relative to this offset. Therefore, the actual register address is **MBAR + 0x3000 + register address**.

Hyperlinks to the FEC registers are provided below:

- FEC ID Register (0x3000)
- FEC Interrupt Event Register (0x3004)
- FEC Interrupt Enable Register (0x3008)
- FEC Rx Descriptor Active Register (0x3010)
- FEC Tx Descriptor Active Register (0x3014)
- FEC Ethernet Control Register (0x3024)
- FEC MII Management Frame Register (0x3040)
- FEC MII Speed Control Register (0x3044)
- FEC MIB Control Register (0x3064)
- FEC Receive Control Register (0x3084)
- FEC Hash Register (0x3088)
- FEC Tx Control Register (0x30C4)
- FEC Physical Address Low Register (0x30E4)
- FEC Physical Address High Register (0x30E8)
- FEC Opcode/Pause Duration Register (0x30EC)
- FEC Descriptor Individual Address 1 Register (0x3118)
- FEC Descriptor Individual Address 2 Register (0x311C)
- FEC Descriptor Group Address 1 Register (0x3120)
- FEC Descriptor Group Address 2 Register (0x3124)
- FEC Tx FIFO Watermark Register (0x3144)
- FEC Rx FIFO Data Register FEC Tx FIFO Data Register (0x3184)
- FEC Rx FIFO Status Register FEC Tx FIFO Status Register (0x31A4)
- FEC Rx FIFO Control Register FEC Tx FIFO Control Register (0x3188)
- FEC Rx/Tx FIFO Status Register (0x31A8)
- FEC Rx/Tx FIFO Control Register (0x318C)
- FEC Rx/Tx FIFO Last Read Frame Pointer Register (0x3190)
- FEC Rx/Tx FIFO Last Write Frame Pointer Register (0x3194)
- FEC Rx/Tx FIFO Alarm Pointer Register (0x3198)
- FEC Rx/Tx FIFO Alarm Pointer Register (0x31B8)
- FEC Rx/Tx FIFO Read Pointer Register (0x319C)
- FEC Rx/Tx FIFO Write Pointer Register (0x31A0)
- FEC Reset Control Register (0x31C4)
- FEC Transmit FSM Register (0x31C8)

### 14.4.3.1 FEC ID Register

The read-only FEC ID Register (FEC_ID) identifies the FEC block and revision.

Address MBAR + 0x3000

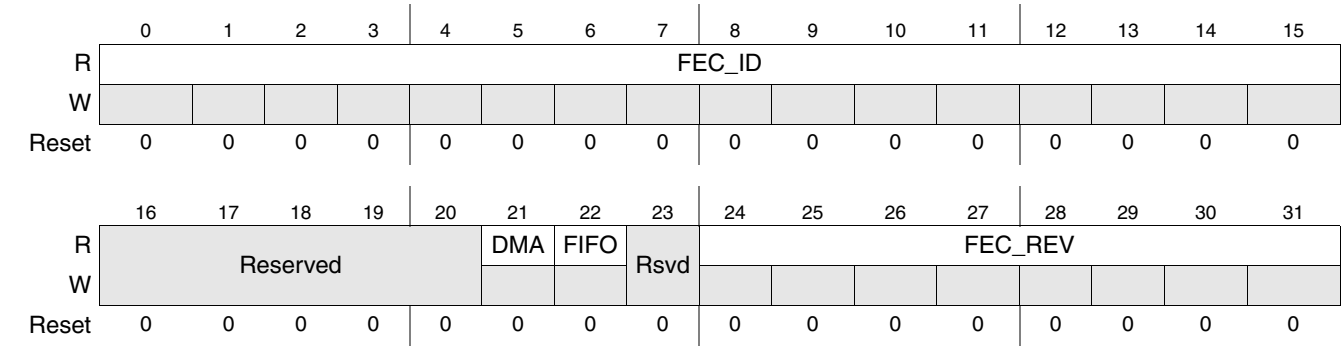



**Figure 14-2. FEC ID Register**

**Table 14-9. FEC ID Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:15 | FEC_ID | Value identifying the FEC |
| 16:20 | — | Reserved |
| 21 | DMA | DMA function is included in the FEC<br>0 FEC does not include DMA (BestComm is the DMA engine) |
| 22 | FIFO | FIFO function included in the FEC<br>1 FEC does include a FIFO |
| 24:31 | FEC_REV | Value identifies the FEC revision |

### 14.4.3.2 FEC Interrupt Event Register

When an event occurs that sets a bit in the IEVENT register, an interrupt is generated if the corresponding bit in the interrupt enable register (IMASK) is also set. The IEVENT register bit is cleared if 1 is written to that bit position. A 0 write has no effect. A hardware reset clears this register.

These interrupts can be divided into operational interrupts, transceiver/network error interrupts and internal error interrupts. Interrupts that may occur in normal operation are:

- GRA
- TFINT
- MII

Interrupts resulting from errors/problems detected in the network or transceiver are:

- HBERR
- BABR
- BABT
- LATE_COL
- COL_RETRY_LIM

Interrupts resulting from FIFO errors are:

- XFIFO_UN
- XFIFO_ERROR
- RFIFO_ERROR

Some error interrupts are independently counted in the MIB block counters. Software may choose to mask these interrupts, since the errors are visible to network management via the MIB counters.

- HBERR – IEEE_T_SQE
- BABR – RMON_R_OVERSIZE (good CRC), RMON_R_JAB (bad CRC)
- BABT – RMON_T_OVERSIZE (good CRC), RMON_T_JAB (bad CRC)
- LATE_COL – IEEE_T_LCOL
- COL_RETRY_LIM – IEEE_T_EXCOL
- XFIFO_UN – IEEE_T_MACERR

Address MBAR + 0x3004

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | HBERR | BABR | BABT | GRA | TFINT | Reserved | | | MII | Rsvd | LATE_COL | COL_<br>RETRY_LIM | XFIFO_UN | XFIFO_<br>ERROR | RFIFO_<br>ERROR | Rsvd |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 14-3. FEC Interrupt Event Register**

**Table 14-10. FEC Interrupt Event Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | HBERR | Heartbeat Error— interrupt bit indicates HBC is set in the X_CNTRL register and COL input was not asserted within the heartbeat window following a transmission. |
| 1 | BABR | Babbling Receive Error—bit indicates frame was received with a length in excess of R_CNTRL.MAX_FL bytes. |
| 2 | BABT | Babbling Transmit Error—bit indicates transmitted frame length exceeded R_CNTRL.MAX_FL bytes. This condition is usually caused by a frame that is too long being placed into the transmit data buffer(s).<br>Truncation does not occur. |

**Table 14-10. FEC Interrupt Event Register Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 3 | GRA | Graceful Stop Complete—interrupt bit is asserted for one of three reasons.<br>1 A graceful stop initiated by setting X_CNTRL.GTS bit is complete.<br>2 A graceful stop initiated by setting X_CNTRL.FC_PAUSE bit is complete.<br>3 A graceful stop initiated by reception of a valid full duplex flow control “pause” frame is complete. Refer to “Full-Duplex Flow Control” section of the Ethernet Operation chapter.<br>A graceful stop means the transmitter is put into a pause state after completion of the frame currently being transmitted. |
| 4 | TFINT | Transmit frame interrupt. This bit indicates that a frame has been transmitted. |
| 5 | — | Reserved |
| 6 | — | Reserved |
| 7 | — | Reserved |
| 8 | MII | MII Interrupt—bit indicates MII completed the data transfer requested. |
| 9 | — | Reserved |
| 10 | LATE_COL | Late Collision bit indicates a collision occurred beyond the collision window (slot time) in half-duplex mode. The frame is truncated with a bad CRC. Remainder of the frame is discarded. |
| 11 | COL_RETRY_LIM | Collision Retry Limit—bit indicates a collision occurred on each of 16 successive attempts to transmit the frame. The frame is discarded without being transmitted and transmission of the next frame begins.<br>Only occurs in half-duplex mode. |
| 12 | XFIFO_UN | Transmit FIFO Underrun—bit indicates the transmit FIFO became empty before the complete frame was transmitted. A bad CRC is appended to the frame fragment and remainder of frame is discarded. |
| 13 | XFIFO_ERROR | Transmit FIFO Error—indicates an error occurred within the transmit FIFO. When XFIFO_ERROR bit is set, ECNTRL.ETHER_EN is cleared, halting FEC frame processing. When this occurs, software must ensure both the FIFO Controller and BestComm are soft-reset. |
| 14 | RFIFO_ERROR | Receive FIFO Error—indicates error occurred within the RX FIFO. When RFIFO_ERROR bit is set, ECNTRL.ETHER_EN is cleared, halting FEC frame processing. When this occurs, software must ensure both the FIFO Controller and BestComm are soft-reset. |
| 15:31 | — | Reserved. |

### 14.4.3.3 FEC Interrupt Enable Register

The IMASK register provides control over the interrupt events allowed to generate an interrupt. All implemented bits in this CSR are R/$\overline{W}$. This register is cleared by a hardware reset. If corresponding bits in both the IEVENT and IMASK registers are set, the interrupt is signalled to the CPU. The interrupt signal remains asserted until 1 is written to the IEVENT bit (write 1 to clear) or a 0 is written to the IMASK bit.

Address MBAR + 0x3008

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | HBEEN | BREN | BTEN | GRAEN | TFIEN | Reserved | | | MIIEN | Rsvd | LCEN | CRLEN | XFUNEN | XFERREN | RFERREN | Rsvd |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 14-4. FEC Interrupt Enable Register**

**Table 14-11. FEC Interrupt Enable Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | HBEEN | Heartbeat Error Interrupt Enable |
| 1 | BREN | Babbling Receiver Interrupt Enable |
| 2 | BTEN | Babbling Transmitter Interrupt Enable |
| 3 | GRAEN | Graceful Stop Interrupt Enable |
| 4 | TFIEN | Transmit Frame Interrupt Enable |
| 5 | — | Reserved |
| 6 | — | Reserved |
| 7 | — | Reserved |
| 8 | MIIEN | MII Interrupt Enable |
| 9 | — | Reserved |
| 10 | LCEN | Late Collision Enable |
| 11 | CRLEN | Late Collision Enable |
| 12 | XFUNEN | Transmit FIFO Underrun Enable |
| 13 | XFERREN | Transmit FIFO Error Enable |
| 14 | RFERREN | Receive FIFO Error Enable |
| 15:31 | — | Reserved |

### 14.4.3.4 FEC Rx Descriptor Active Register

The FEC descriptor active register is a command register which should be written by the user to indicate that the receive descriptor ring has been updated (empty receive buffers have been produced by the driver with the E bit set).

Whenever the register is written the R_DES_ACTIVE bit is set. This is independent of the data actually written by the user. When set, the FEC will poll the receive descriptor ring and process receive frames (provided ETHER_EN is also set). Once the FEC polls a receive descriptor whose ownership bit is not set, then the FEC will clear the R_DES_ACTIVE bit and cease receive descriptor ring polling until the user sets the bit again, signifying additional descriptors have been placed into the receive descriptor ring.

The R_DES_ACTIVE bit is cleared at reset and by the clearing of ETHER_EN.

Address MBAR + 0x3010

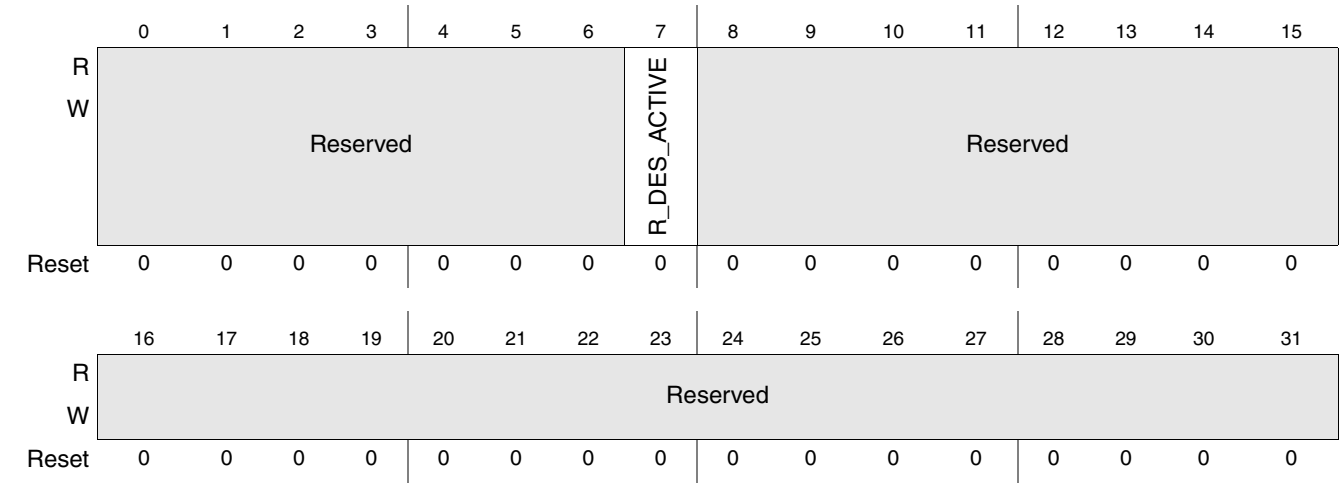



**Figure 14-5. FEC Rx Descriptor Active Register**

**Table 14-12. FEC Rx Descriptor Active Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7 | R_DES_ACTIVE | Set to one when this register is written, regardless of the value written. Cleared by the FEC device whenever no additional “ready” descriptors remain in the receive ring. |
| 8:31 | — | Reserved |

### 14.4.3.5 FEC Tx Descriptor Active Register

The FEC descriptor active register is a command register which should be written by the user to indicate that the transmit descriptor ring has been updated (transmit buffers have been produced by the driver with the R bit set in the buffer descriptor).

Whenever the register is written the X_DES_ACTIVE bit is set. This is independent of the data actually written by the user. When set, the FEC will poll the transmit descriptor ring and process transmit frames (provided ETHER_EN is also set). Once the FEC polls a transmit descriptor whose ownership bit is not set, then the FEC will clear the X_DES_ACTIVE bit and cease transmit descriptor ring polling until the sets the bit again, signifying additional descriptors have been placed into the transmit descriptor ring.

The X_DES_ACTIVE bit is cleared at reset and by the clearing of ETHER_EN.

Address MBAR + 0x3014

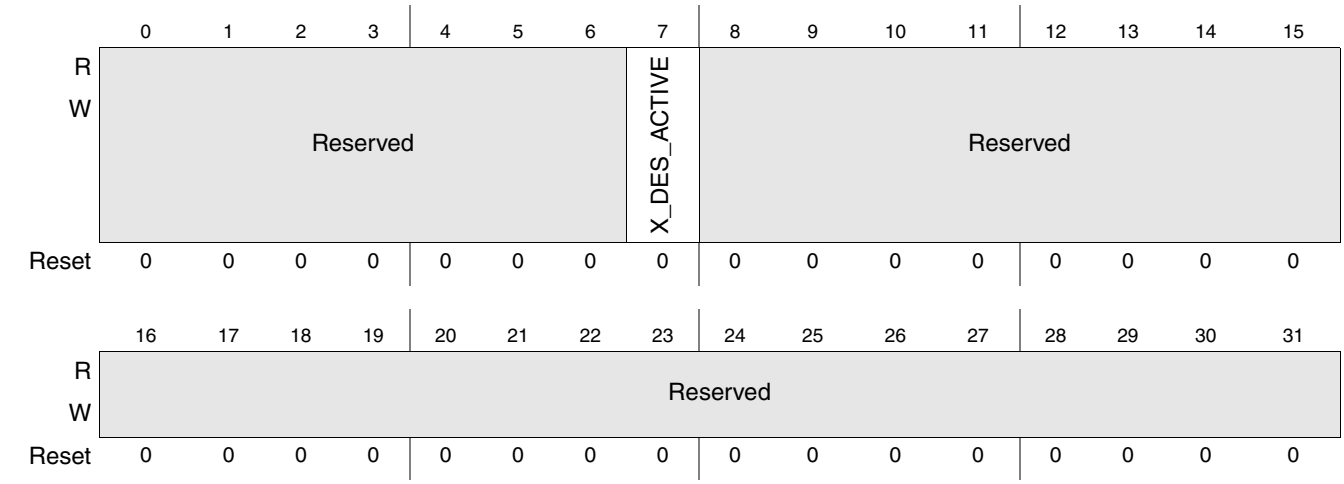



**Figure 14-6. FEC Tx Descriptor Active Register**

**Table 14-13. FEC Tx Descriptor Active Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7 | X_DES_ACTIVE | Set to one when this register is written, regardless of the value written. Cleared by the FEC device whenever no additional “ready” descriptors remain in the transmit ring. |
| 8:31 | — | Reserved |

### 14.4.3.6 FEC Ethernet Control Register

The ECNTRL register is a read/write user register that can enable/disable the FEC. Some fields may be altered by hardware.

Address MBAR + 0x3024

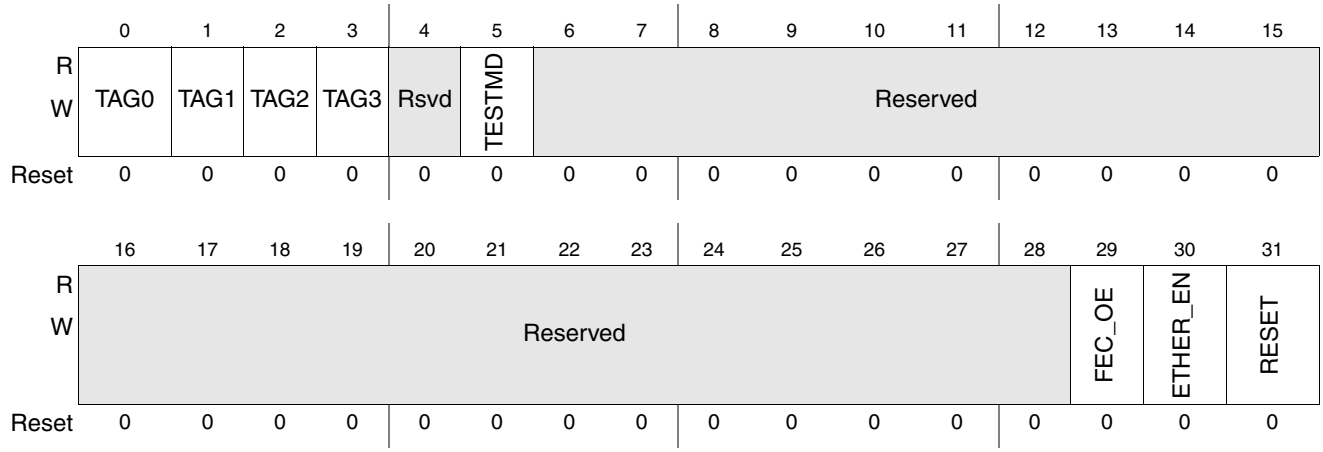



**Figure 14-7. FEC Ethernet Control Register**

**Table 14-14. FEC Ethernet Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | TAG[0:3] | This field allows programming and reading the TBUS tag bits. This field is used for debug/test only, and is implemented in two separate 4-bit registers. The tags_in register is written to when a write to this register takes place. This field (tags_in) resets to 1111. During a write cycle to any FEC register other than ECNTRL the tags_in value is driven onto the tbus data bus tag field. During a read cycle the tbus tag field bits is latched and saved in the tags_out register. When the ECNTRL register is read the value from tags_out shows in the TAG field. |
| 4 | — | Reserved |
| 5 | TESTMD | Test Mode—used for manufacturing test only. TESTMD resets to 0. This bit forces the bus controller to ignore all bus requests except the one from the SIF. |
| 6:28 | — | Reserved |
| 29 | FEC_OE | FEC Output Enable—It is a spare bit and has no affect on internal operation. |
| 30 | ETHER_EN | Ethernet Enable—When this bit is set, FEC is enabled and Rx/Tx can occur. When bit is cleared, Rx stops immediately; Tx stops after a bad CRC is appended to any frame currently being transmitted. The ETHER_EN bit is altered by hardware under the following conditions:<br>• If ECNTRL.RESET is written to 1 by software, ETHER_EN is cleared.<br>• If error conditions causing the IEVENT.EBERR, XFIFO_ERROR or RFIFO_ERROR bits to set occur ETHER_EN is cleared. |
| 31 | RESET | Ethernet Controller Reset—When this bit is set, the equivalent of a hardware reset is done, but it is local to the FEC. ETHER_EN is cleared and all other FEC registers take their reset values. Also, any Tx/Rx currently in progress is abruptly aborted. This bit is automatically cleared by hardware during the reset sequence. The reset sequence takes approximately 8 clock cycles after RESET is written with 1. |

### 14.4.3.7 FEC MII Management Frame Register

This MII_DATA register does not reset to a defined value. The MII_DATA register is used to communicate with the attached MII compatible PHY device(s), providing read/write access to the MII registers.

Writing to the MII_DATA register causes a management frame to be sourced unless the MII_SPEED register has been programmed to 0. When writing to MII_DATA when MII_SPEED = 0, if the MII_SPEED register is then written to a non-zero value, an MII frame is generated with the data previously written to the MII_DATA register. This let MII_DATA and MII_SPEED be programmed in either order if MII_SPEED is currently 0.

Address MBAR + 0x3040

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | ST | | OP | | PA | | | | | RA | | | | | TA | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | DATA | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

**Note:** X: Bit does not reset to a defined value.

**Figure 14-8. FEC MII Management Frame Register**

**Table 14-15. FEC MII Management Frame Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:1 | ST | Start of Frame Delimiter—bits must be programmed to 01 for a valid MII management frame. |
| 2:3 | OP | Operation Code—field must be programmed to 10 (read) or 01 (write) to generate a valid MII management frame.<br>• A value of 11 causes a “read” frame operation.<br>• A value of 00 causes a “write” frame operation. However, these frames are not MII compliant. |
| 4:8 | PA | PHY Address—specifies 1 of up to 32 attached PHY devices. |
| 9:13 | RA | Register Address—specifies 1 of up to 32 registers within the specified PHY device. |
| 14:15 | TA | TurnAround—must be programmed to 10 to generate a valid MII management frame. |
| 16:31 | DATA | Management Frame Data—used for data written to or read from PHY register. |

To do a read or write operation the MII management interface writes to the MII_DATA register. To generate a valid read or write management frame:

- the ST field must be written with a 01
- the OP field must be written with either:
  - 01 (management register write frame), or
  - 10 (management register read frame), and
- the TA field must be written with a 10

If other patterns are written to these fields, a frame is generated, but it does not comply to the IEEE 802.3 MII definition:

- OP field = 1x produces a “read” frame operation, while
- OP field = 0x produces a “write” frame operation.

To generate an IEEE 802.3 compliant MII management interface write frame (write to a PHY register), the user must write the following to the MII_DATA register:

{01 01 PHYAD REGAD 10 DATA}

Writing this pattern causes control logic to shift out the data in the MII_DATA register following a preamble generated by the control state machine. During this time, the MII_DATA register contents are altered as the contents are serially shifted, and is unpredictable if read by the user. When the write management frame operation is complete, the MII_DATAIO_COMPL interrupt is generated. At this time the MII_DATA register contents match the original value written.

To generate an MII Management Interface read frame (read a PHY register) the user must write the following to the MII_DATA register (DATA field content is don’t care):

{01 10 PHYAD REGAD 10 XXXX}

Writing this pattern causes control logic to shift out data in the MII_DATA register following a preamble generated by the control state machine. During this time, the MII_DATA register contents are altered as the contents are serially shifted, and is unpredictable if read by the user. When the read management frame operation is complete, the MII_DATAIO_COMPL interrupt is generated. At this time the MII_DATA register contents matches the original value written, except for the DATA field whose contents have been replaced by the value read from the PHY register.

If the MII_DATA register is written while frame generation is in progress, frame contents are altered. Software should use the MII_STATUS register and/or the MII_DATAIO_COMPL interrupt to avoid writing to the MII_DATA register while frame generation is in process.

### 14.4.3.8 FEC MII Speed Control Register

The MII_SPEED register provides MII clock (MDC pin) frequency control. This allows dropping the MII management frame preamble and provides observability (intended for manufacturing test) of an internal counter used in generating an MDC clock signal.

Address MBAR + 0x3044

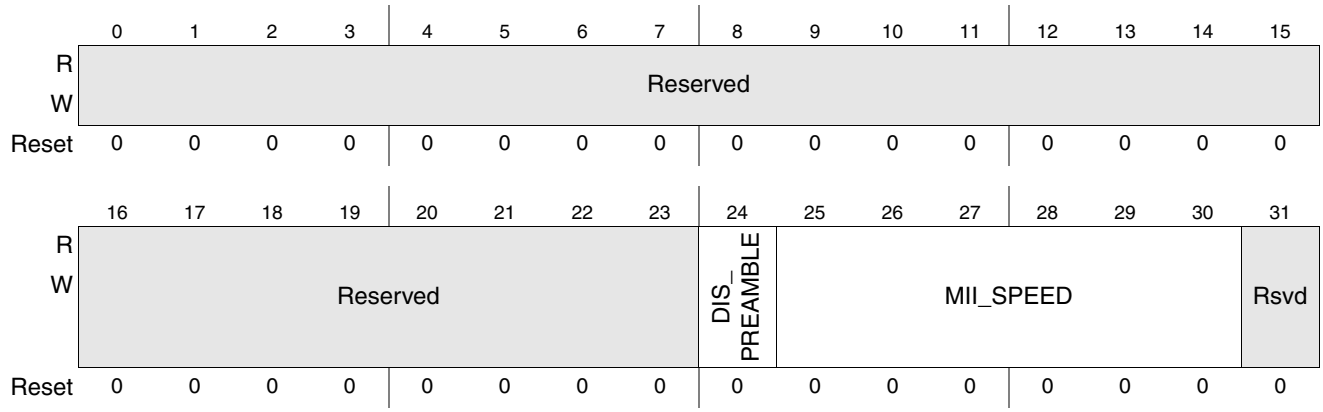



**Figure 14-9. FEC MII Speed Control Register**

**Table 14-16. FEC MII Speed Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:23 | — | Reserved |
| 24 | DIS_PREAMBLE | Asserting this bit causes preamble (32 1s) to not be prepended to the MII management frame. The MII standard allows the preamble to be dropped, if not required by the attached PHY device(s). |
| 25:30 | MII_SPEED | Controls the frequency of the MII management interface clock (MDC) relative to ipb_clk. A 0 value in this field “turns off” the MDC and leaves it in low voltage state. Any non-zero value results in the MDC frequency of<br>1/(MII_SPEED*2) of the ipb_clk frequency.<br>The MII_SPEED field must be programmed with a value to provide an MDC frequency of less than or equal to 2.5 MHz to be compliant with the IEEE MII characteristic. The MII_SPEED must be set to a non-zero value in order to source a read or write management frame. After the management frame is complete, the MII_SPEED register may optionally be set to 0 to turn off the MDC. The MDC generated has a 50% duty cycle except when MII_SPEED is changed during operation (change takes affect following either a rising or falling edge of MDC).<br>If the ipb_clk is 25MHz, programming MII_SPEED field to 0x5 results in a MDC frequency of 25MHz * 1/(5*2) = 2.5 MHz. Table 14-17 shows MII_SPEED optimum values as a function of the ipb_clk frequency. |
| 31 | — | Reserved |

**Table 14-17. Programming Examples for MII_SPEED Register**

| ipb_clk Frequency | MII_SPEED (Field in Register) | MDC Frequency |
|---|---|---|
| 25MHz | $5 | 2.5MHz |
| 33MHz | $7 | 2.36MHz |
| 40MHz | $8 | 2.5MHz |
| 50MHz | $A | 2.5MHz |

### 14.4.3.9 FEC MIB Control Register

The MIB_CONTROL register is a read/write register used to provide control of and to observe the state of the MIB block. This register is accessed by user software if there is a need to disable the MIB block operation. For example, to clear all MIB counters in RAM the user should disable the MIB block, clear all MIB RAM locations, then enable the MIB block. The MIB_DISABLE bit is reset to 1.

Address MBAR + 0x3064

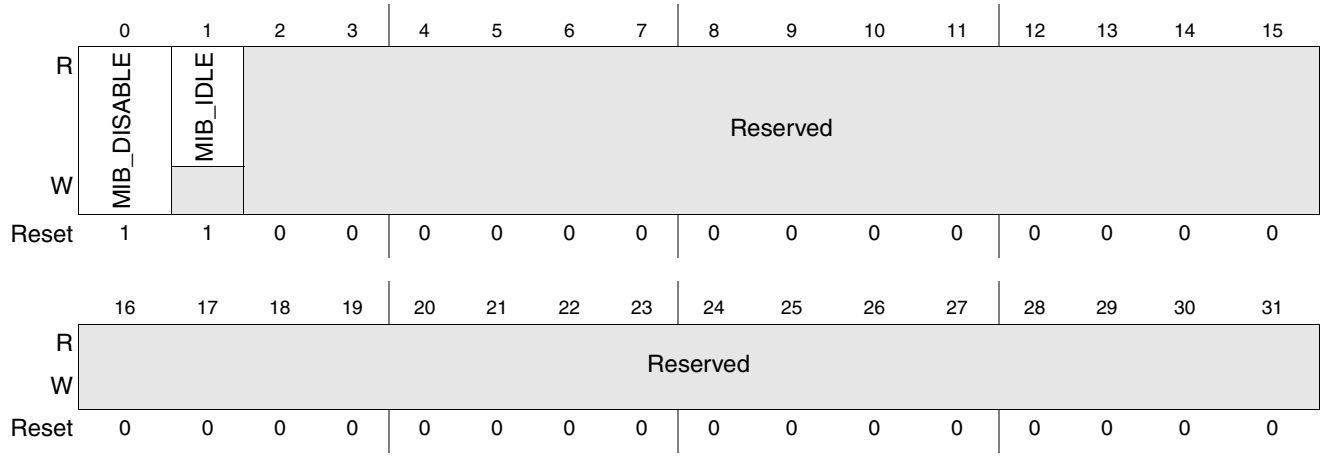



**Figure 14-10. FEC MIB Control Register**

**Table 14-18. FEC MIB Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | MIB_DISABLE | A read/write control bit. If set, MIB logic halts and MIB counters do not update. |
| 1 | MIB_IDLE | A read-only status bit. If set, MIB block is not currently updating MIB counters. |
| 2:31 | — | Reserved |

### 14.4.3.10 FEC Receive Control Register

The R_CNTRL register is user programmable. It controls the operational mode of the receive block and should be written only when ETHER_EN = 0 (initialization time).

Address MBAR + 0x3084

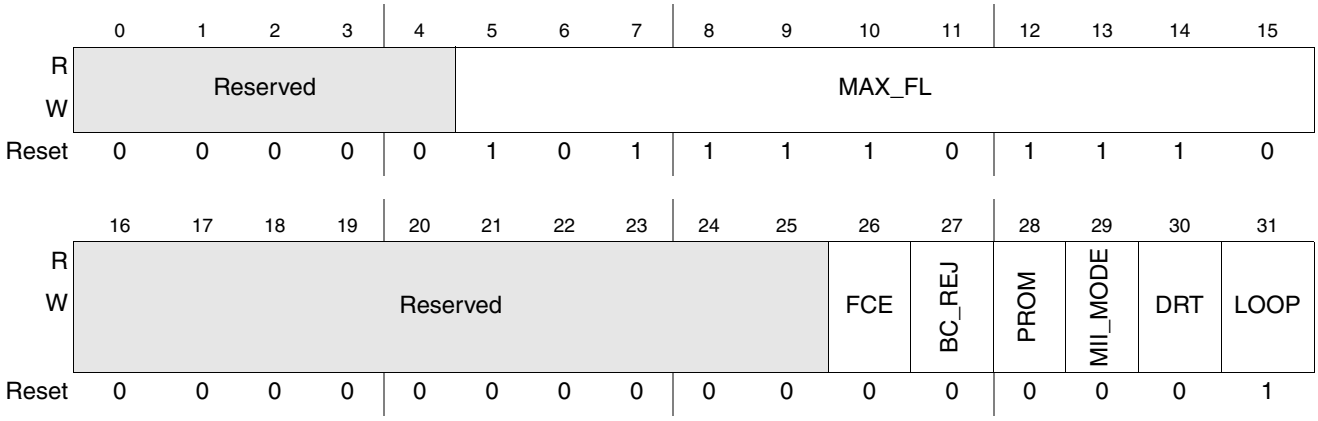



**Figure 14-11. FEC Receive Control Register**

**Table 14-19. FEC Receive Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:4 | — | Reserved |
| 5:15 | MAX_FL | Maximum Frame Length—User R/W field. Resets to decimal 1518. The length is measured starting at DA and includes CRC at End Of Frame (EOF). Tx frames longer than MAX_FL causes the BABT interrupt to occur. Rx Frames longer than MAX_FL causes BABR interrupt to occur and sets the EOF Receive Frame Status Word LG bit. The recommended user programmed default value is 1518, or if VLAN Tags are supported, 1522. |
| 16:25 | — | Reserved |
| 26 | FCE | Flow Control Enable—If asserted, the receiver detects PAUSE frames. On PAUSE frame detection, transmitter stops transmitting data frames for a given duration. |
| 27 | BC_REJ | Broadcast Frame Reject—If asserted, frames with DA (destination address) = FFFF_FFFF_FFFF are rejected, unless PROM bit is set. If both BC_REJ and PROM = 1, frames with broadcast DA are accepted and M (MISS) bit is set in the Rx buffer descriptor. |
| 28 | PROM | Promiscuous mode—All frames are accepted regardless of address matching. |
| 29 | MII_MODE | Selects External Interface Mode—controls the interface mode for Tx/Rx blocks.<br>• Setting bit to 1 selects MII mode.<br>• Setting bit to 0 selects 7wire mode (used only for serial 10Mbps). |
| 30 | DRT | Disable Receive on Transmit<br>0 = Rx path operates independently of Tx (use for full-duplex or to monitor Tx activity in half-duplex mode).<br>1 = Disable frames reception while transmitting (normally used for half-duplex mode). |
| 31 | LOOP | Internal Loopback—If set, transmitted frames are looped back internal to the device and transmit output signals are not asserted. The system clock is substituted for TX_CLK when LOOP is asserted. DRT must be set to 0 when asserting LOOP. |

### 14.4.3.11 FEC Hash Register

The read-only R_HASH register provides address recognition information from the Rx block about the frame currently being received. These bits provide information used in the address recognition subroutine.

Address MBAR + 0x3088

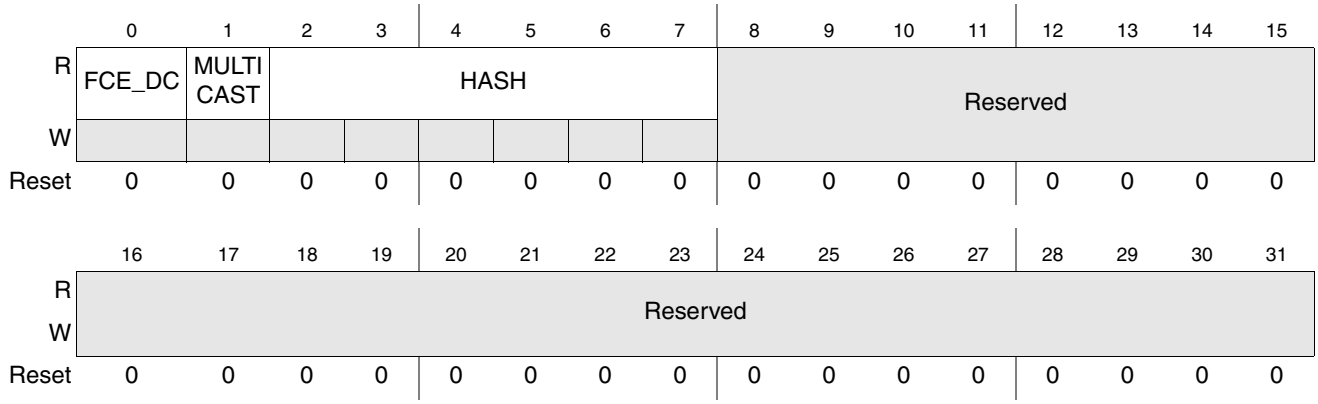



**Figure 14-12. FEC Hash Register**

**Table 14-20. FEC Hash Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | FCE_DC | This is a read-only view of the R_CNTRL register FCE bit. |
| 1 | MULTICAST | Set if current Rx frame contained a multi-cast destination address, indicating DA LSB was set. Cleared if current Rx frame does not correspond to a multi-cast address. |
| 2:7 | HASH | Corresponds to “hash” value of current Rx frame’s destination address. Hash value is a 6-bit field extracted from least significant portion of CRC register. |
| 8:31 | — | Reserved |

### 14.4.3.12 FEC Tx Control Register

This X_CNTRL register is read/write and is written to configure the transmit block. This register is cleared at system reset. Bits 29:30 should be modified only when ETHER_EN = 0.

Address MBAR + 0x30C4

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | RFC_PAUSE | TFC_PAUSE | FDEN | HBC | GTS |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 14-13. FEC Tx Control Register**

**Table 14-21. FEC Tx Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:26 | — | Reserved |
| 27 | RFC_PAUSE | This read-only status bit is asserted when a full-duplex flow control pause frame is received. The transmitter is paused for the duration defined in this pause frame. Bit automatically clears when the pause duration is complete. |
| 28 | TFC_PAUSE | Assert to transmit a PAUSE frame. When this bit is set, the MAC stops transmission of data frames after the current transmission is complete. At this time, the INTR_EVENT register GRA interrupt is asserted. With transmission of data frames stopped, the MAC transmits a MAC Control PAUSE frame. Next, the MAC clears the TFC_PAUSE bit and resumes transmitting data frames.<br>**Note:** If the transmitter is paused due to user assertion of GTS or reception of a PAUSE frame, MAC may still transmit a MAC Control PAUSE frame. |
| 29 | FDEN | Full Duplex Enable—If set, frames are transmitted independent of Carrier Sense and Collision inputs.<br>This bit should only be modified when ETHER_EN is deasserted. |
| 30 | HBC | Heartbeat Control—If set, the heartbeat check is done following End Of Transmission (EOT) and the Event Status Register HB bit is set if the collision input does not assert within the heartbeat window.<br>This bit should only be modified when ETHER_EN is deasserted. |
| 31 | GTS | Graceful Transmit Stop—When this bit is set, the MAC stops transmission after any frame that is currently being transmitted is complete and the INTR_EVENT register GRA interrupt is asserted.<br>If frame transmission is not currently underway, the GRA interrupt is immediately asserted.<br>Once transmission completes, a “restart” can be done by clearing the GTS bit. The next frame in the transmit FIFO is then transmitted.<br>If an early collision occurs during transmission when GTS = 1, transmission stops after the collision. The frame is transmitted again once GTS is cleared.<br>**Note:** Old frames may exist in the transmit FIFO and be transmitted when GTS is reasserted. To avoid this, deassert ETHER_EN after the GRA interrupt. |

### 14.4.3.13 FEC Physical Address Low Register

The PADDR1 register is written by the user. This register contains the lower 32 bits (Bytes 0, 1, 2, 3) of the 48-bit address used in the address recognition process to compare with the destination address (DA) field of receive frames with an individual DA. In addition, this register is used in Bytes 0:3 of the 6-Byte source address field when transmitting PAUSE frames. This register is not reset and must be initialized.

Address MBAR + 0x30E4

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | PADDR1 | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | PADDR1 | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

**Note:** X: Bit is not reset and must be initialized.

**Figure 14-14. FEC Physical Address Low Register**

**Table 14-22. FEC Physical Address Low Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | PADDR1 | Bytes 0 (bits 31:24), 1 (bits 23:16), 2 (bits 15:8) and 3 (bits 7:0) of the 6-byte individual address used for an exact match, and the Source Address field in PAUSE frames. |

### 14.4.3.14 FEC Physical Address High Register

The PADDR2 register is written by the user. This register contains the upper 16 bits (bytes 4 and 5) of the 48-bit address used in the address recognition process to compare with the destination address (DA) field of receive frames with an individual DA. In addition, this register is used in Bytes 4 and 5 of the 6-Byte source address field when transmitting PAUSE frames. Bits 16:31 of XMIT.PADDR2 contain a constant type field (hex 8808) used for transmission of PAUSE frames. This register is not reset and bits 0:15 must be initialized.

Address MBAR + 0x30E8

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | PADDR2 | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | TYPE | | | | | | | | | | | | | | | |
| Reset | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

**Note:** X: Bit is not reset and must be initialized.

**Figure 14-15. FEC Physical Address High Register**

**Table 14-23. FEC Physical Address High Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:15 | PADDR2 | Bytes 4 (bits 31:24) and 5 (bits 23:16) of the 6-byte individual address used for an exact match, and the Source Address field in PAUSE frames. |
| 16:31 | TYPE | These 16 bits are a constant value, hex 8808. |

### 14.4.3.15 FEC Opcode/Pause Duration Register

The OP_PAUSE register is read/write accessible. This register contains the 16-bit opcode, and 16-bit pause duration fields used in transmission of a PAUSE frame. The opcode field is a constant value, hex 0001. When another node detects a PAUSE frame, that node pauses transmission for the duration specified in the pause duration field. This register is not reset and bits 16:31 must be initialized.

Address MBAR + 0x30EC

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | OPCODE | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | PAUSE_DUR | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

**Note:** X: Bit is not reset and must be initialized.

**Figure 14-16. FEC Opcode/Pause Duration Register**

**Table 14-24. FEC Opcode/Pause Duration Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:15 | OPCODE | Opcode field used in PAUSE frames. Bits are a constant value, hex 0001. |
| 16:31 | PAUSE_DUR | Pause Duration field used in PAUSE frames. |

### 14.4.3.16 FEC Descriptor Individual Address 1 Register

The IADDR1 register is written by the user. This register contains the upper 32 bits of the 64-bit individual address hash table used in the address recognition process to check for possible match with the DA field of receive frames with an individual DA. This register is not reset and must be initialized.

Address MBAR + 0x3118

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IADDR1 | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IADDR1 | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

**Note:** X: Bit is not reset and must be initialized.

**Figure 14-17. FEC Descriptor Individual Address 1 Register**

**Table 14-25. FEC Descriptor Individual Address 1 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | IADDR1 | The upper 32 bits of the 64-bit hash table used in the address recognition process for receive frames with a unicast address.<br>• Bit 31 contains hash index bit 63.<br>• Bit 0 contains hash index bit 32. |

### 14.4.3.17 FEC Descriptor Individual Address 2 Register

The IADDR2 register is written by the user. This register contains the lower 32 bits of the 64-bit individual address hash table used in the address recognition process to check for possible match with the DA field of receive frames with an individual DA. This register is not reset and must be initialized.

Address MBAR + 0x311C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IADDR2 | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | IADDR2 | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

**Note:** X: Bit is not reset and must be initialized.

**Figure 14-18. FEC Descriptor Individual Address 2 Register**

**Table 14-26. FEC Descriptor Individual Address 2 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | IADDR2 | The lower 32 bits of the 64-bit hash table used in the address recognition process for receive frames with a unicast address.<br>• Bit 31 contains hash index bit 31.<br>• Bit 0 contains hash index bit 0. |

### 14.4.3.18 FEC Descriptor Group Address 1 Register

The GADDR1 register is written by the user. This register contains the upper 32 bits of the 64-bit hash table used in the address recognition process for receive frames with a multicast address. This register must be initialized.

Address MBAR + 0x3120

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | GADDR1 | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | GADDR1 | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

**Note:** X: Bit is not reset and must be initialized.

**Figure 14-19. FEC Descriptor Group Address 1 Register**

**Table 14-27. FEC Descriptor Group Address 1 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | GADDR1 | The GADDR1 register contains the upper 32 bits of the 64-bit hash table used in the address recognition process for receive frames with a multicast address.<br>• Bit 31 contains hash index bit 63.<br>• Bit 0 contains hash index bit 32. |

### 14.4.3.19 FEC Descriptor Group Address 2 Register

The GADDR2 register is written by the user. The GADDR2 register contains the lower 32bits of the 64-bit hash table used in the address recognition process for receive frames with a multicast address. This register must be initialized.

Address MBAR + 0x3124

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | GADDR2 | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | GADDR2 | | | | | | | | | | | | | | | |
| Reset | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

**Note:** X: Bit is not reset and must be initialized.

**Figure 14-20. FEC Descriptor Group Address 2 Register**

**Table 14-28. FEC Descriptor Group Address 2 Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:31 | GADDR2 | The GADDR2 register contains the lower 32bits of the 64-bit hash table used in the address recognition process for receive frames with a multicast address.<br>• Bit 31 contains hash index bit 31.<br>• Bit 0 contains hash index bit 0. |

### 14.4.3.20 FEC Tx FIFO Watermark Register

The X_WMRK register is a user programmable 4-bit read/write register that controls the amount of data required in the transmit FIFO before transmission of a frame can begin. This lets the user minimize transmit latency (X_WMRK = 0000) or allows for larger bus access latency (X_WMRK = 1111) due to contention for the system bus. Setting the watermark to a high value minimizes the risk of transmit FIFO underrun due to contention for the system bus. The X_WMRK register resets to 0.

**NOTE**

This register value may need to be customized by software for specific FEC applications to be compatible with specific FIFO/system bus access latency requirements.

Address MBAR + 0x3144

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | X_WMRK | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 14-21. FEC Tx FIFO Watermark Register**

**Table 14-29. FEC Tx FIFO Watermark Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:28 | — | Reserved |
| 28:31 | X_WMRK | Transmit FIFO Watermark—Frame transmission begins:<br>• If the number of bytes selected by this field are written into the transmit FIFO, or<br>• if an EOF is written to the FIFO, or<br>• if the FIFO is full before the selected number of bytes are written.<br>Options are:<br>0000 64 Bytes written to FIFO<br>0001 128 Bytes written to FIFO<br>0010 192 Bytes written to FIFO<br>0011 256 Bytes written to FIFO<br>0100 320 Bytes written to FIFO<br>0101 384 Bytes written to FIFO<br>0110 448 Bytes written to FIFO<br>0111 512 Bytes written to FIFO<br>1000 576 Bytes written to FIFO<br>1001 640 Bytes written to FIFO<br>1010 704 Bytes written to FIFO<br>1011 768 Bytes written to FIFO<br>1100 832 Bytes written to FIFO<br>1101 896 Bytes written to FIFO<br>1110 960 Bytes written to FIFO<br>1111 1024 Bytes written to FIFO |

### 14.4.4 FIFO Interface

The programming interface to the FIFO allows access to Data, Status, Control, Last Write Pointer, Last Read Pointer, Alarm, Read and Write Pointers for Transmit and Receive configurations. The FIFO can be accessed by byte, word, or longword, but all accesses must be aligned with the most significant byte (big endian) of the data port. BestComm supports byte, word or longword accesses. The processor supports longword access only. All register name access is longword aligned

**Table 14-30. FIFO Interface Register Map**

| Address | byte0 | byte1 | byte2 | byte3 | Description |
|---|---|---|---|---|---|
| 0x184 | Data | Data | Data | Data | Receive FIFO Data |
| 0x188 | Stat | Stat | | | Receive FIFO Status |
| 0x18C | Ctl | | | | Receive FIFO Control |
| 0x190 | | | LRF | LRF | Receive Last Read Frame Pointer |
| 0x194 | | | LWF | LWF | Receive Last Write Frame Pointer |
| 0x198 | | | Alarm | Alarm | Receive (High/Low) Alarm Pointer |
| 0x19C | | | Read | Read | Receive FIFO Read Pointer |
| 0x1A0 | | | Write | Write | Receive FIFO Write Pointer |
| 0x1A4 | Data | Data | Data | Data | Transmit FIFO Data |
| 0x1A8 | Stat | Stat | | | Transmit FIFO Status |
| 0x1AC | Ctl | | | | Transmit FIFO Control |
| 0x1B0 | | | LRF | LRF | Transmit Last Read Frame Pointer |
| 0x1B4 | | | LWF | LWF | Transmit Last Write Frame Pointer |
| 0x1B8 | | | Alarm | Alarm | Transmit (High/Low) Alarm Pointer |
| 0x1BC | | | Read | Read | Transmit FIFO Read Pointer |
| 0x1C0 | | | Write | Write | Transmit FIFO Write Pointer |

### 14.4.4.1 FEC Rx FIFO Data Register
### FEC Tx FIFO Data Register

The RFIFO_DATA (MBAR + 0x3184) and TFIFO_DATA (MBAR + 0x31A4) registers are the main interface port for the transmit and receive FIFO. Data which is to be buffered in the FIFO, or has been buffered in the FIFO, is accessed through this register.

### 14.4.4.2 FEC Rx FIFO Status Register
### FEC Tx FIFO Status Register

The RFIFO_STATUS and TFIFO_STATUS registers contain bits which provide information about the status of the FIFO controller. The bits marked sticky are cleared by writing a “1” to their positions.

Address MBAR + 0x3188, 0x31A8

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | IP | TXW | TYPE [1] | TYPE [0[ | Frame[0:3] | | | | FAE | RXW | UF | OF | FR | Full | Alarm | Empty |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

**Figure 14-22. FEC Rx/Tx FIFO Status Register**

**Table 14-31. FEC Rx/Tx FIFO Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:7 | Frame[0:3] | Frame Indicator – READ ONLY<br>This bus provides a frame status indicator for non-DMA applications.<br>Frame[0] = A frame boundary has occurred on the [31:24] byte of the data bus.<br>Frame[1] = A frame boundary has occurred on the [23:16] byte of the data bus.<br>Frame[2] = A frame boundary has occurred on the [15:8] byte of the data bus.<br>Frame[3] = A frame boundary has occurred on the [7:0] byte of the data bus. |
| 8 | — | Reserved |
| 9 | Error | FIFO Error – Sticky, Write To Clear.<br>This bit signifies that an error has occurred in the FIFO controller. Errors can be caused by underflow, overflow, or pointers being out of bounds. This bit will remain set until this bit of the FIFO status register has been written with a 1. |
| 10 | UF | UF FIFO Underflow – Sticky, Write To Clear<br>This bit signifies the read pointer has surpassed the write pointer. This bit will remain set until this bit of the FIFO status register has been written with a 1. |
| 11 | OF | OF FIFO Overflow – Sticky, Write To Clear<br>This bit signifies the write pointer has surpassed the read pointer. This bit will remain set until this bit of the FIFO status register has been written with a 1. |

**Table 14-31. FEC Rx/Tx FIFO Status Register Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 12 | FR | FR Frame Ready – Read Only<br>The FIFO has requested attention because there is framed data ready. All complete frames must be read from the FIFO to clear this alarm. This alarm will only be asserted while in frame mode. |
| 13 | Full | Full Alarm – Read Only<br>The FIFO has requested attention because it is full. The FIFO must be read to clear this alarm. |
| 14 | Alarm | FIFO Alarm – Read Only<br>The FIFO has requested attention because it has determined an alarm condition. The specific alarm condition detected is dependent upon the FIFO direction (Transmit or Receive); if it is a Transmit FIFO, then the FIFO alarm output pin provides indication of a low level, asserting when there is less than alarm bytes of data remaining in the FIFO, and deasserting when there are less than 4* granularity free bytes remaining. When the FIFO is configured to Receive, the FIFO alarm provides high level indication, asserting when there are less than alarm bytes free in the FIFO, and deasserting when there are less than granularity bytes of data remaining. This signal can be cleared by reading or writing (as appropriate) the FIFO, or manipulating the FIFO pointers. |
| 15 | Empty | Empty – Read Only<br>The FIFO has requested attention because it is empty. The FIFO must be written to clear this alarm. |
| 16:31 | — | Reserved |

### 14.4.4.3 FEC Rx FIFO Control Register FEC Tx FIFO Control Register

The RFIFO_CONTROL and TFIFO_CONTROL registers provide programmability of many FIFO behaviors, from last transfer granularity to frame operation. Last transfer granularity allows the user to control when the FIFO controller stops requesting data transfers through the FIFO alarm. When the alarm is configured as a Receive FIFO, the granularity value is the GR[2:0] value. When the alarm is configured as a Transmit FIFO, the granularity value is four times the GR[2:0] value, or the pipeline depth. The frame bit of the control register provides a capability to enable and control the FIFO controller's ability to view data on a packetized basis. The FIFO controller also has the programmable capability to not request attention after it has received a complete frame until Ethernet has reported completion of transmission. Frame mode supersedes the FIFO granularity bits, through the assertion of a hardware signal to BestComm.

Address MBAR + 0x318C, 0x31AC

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Shadow | WFR[1:0] | | COMP | FRAME | GR[2:0] | | | IP MASK | FAE MASK | RXW MASK | UF MASK | OF MASK | TXW MASK | Reserved | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 14-23. FEC Rx/Tx FIFO Control Register**

**Table 14-32. FEC Rx/Tx FIFO Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | — | Reserved |
| 1:2 | WFR[1:0] | Write Frame<br>01 The FIFO controller assumes the next write to its data port is the next to last write.<br>10 The FIFO controller assumes the next write to its data port is status / control information. |
| 3 | COMP | COMP Re-enable Requests on Frame Transmission Completion.<br>When this bit is set, the FIFO controller will not request attention between receiving the last data of the frame from the BestComm until the peripheral acknowledges transmission of the frame. |
| 4 | FRAME | Frame Mode Enable.<br>When this bit is set, the FIFO controller monitors frame done information from the peripheral or BestComm. Setting this bit also enables the other frame control bits in this register, as well as other frame functions. This bit must be set to use frame functions. |
| 5:7 | GR[2:0] | Last Transfer Granularity.<br>These bits define the deassertion point for the "high" service request and also define the deassertion point for the "low" service request. A "high" service request is deasserted when there are less than GR[2:0] data bytes remaining in the FIFO. A "low" service request is deasserted when there are less than (4 * GR[2:0]) free bytes remaining in the FIFO. |

### 14.4.4.4 FEC Rx FIFO Last Read Frame Pointer Register FEC Tx FIFO Last Read Frame Pointer Register

The RFIFO_LRF_PTR and TFIFO_LRF_PTR are a FIFO-maintained pointer which indicates the location of the start of the most recently read frame, or the start of the frame currently in transmission. The LRFP updates on FIFO read data accesses to a frame boundary. The LRFP can be read and written for debug purposes. For the frame retransmit function, the LRFP indicates which point to begin retransmission of the data frame. The LRFP carries validity information, however, there are no safeguards to prevent retransmitting data which has been overwritten. When FRAME is not set, then this pointer has no meaning.

Address MBAR + 0x3190, 0x31B0

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | LRFP[9:0] | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 14-24. FEC Rx/Tx FIFO Last Read Frame Pointer Register**

**Table 14-33. FEC Rx/Tx FIFO Last Read Frame Pointer Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:21 | — | Reserved |
| 22:31 | LRFP[9:0] | LRFP Last Read Frame Pointer.<br>This pointer indicates the start of the last data frame read from the FIFO by the peripheral. |

### 14.4.4.5 FEC Rx FIFO Last Write Frame Pointer Register FEC Tx FIFO Last Write Frame Pointer Register

The RFIFO_LWF_PTR and TFIFO_LWF_PTR are a FIFO maintained pointer which indicates the location of the start of the last frame written into the FIFO. The LWFP updates on FIFO write data accesses which create a frame boundary, whether that be by setting the WFC control bit or by feeding a frame bit in on the appropriate bus. The LWFP can be read and written for debug purposes. For the frame discard function, the LWFP divides the valid data region of the FIFO (the area in-between the read and write pointers) into framed and unframed data. Data between the LWFP and write pointer constitutes an incomplete frame, while data between the read pointer and the LWFP has been received as whole frames. When FRAME is not set, then this pointer has no meaning.

Address MBAR + 0x3194, 0x31B4

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | LRFP[9:0] | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 14-25. FEC Rx/Tx FIFO Last Write Frame Pointer Register**

**Table 14-34. FEC Rx/Tx FIFO Last Write Frame Pointer Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:21 | — | Reserved |
| 22:31 | LWFP[9:0] | LRFP Last WriteFrame Pointer.<br>This pointer indicates the start of the last data frame written into the FIFO by the peripheral. |

### 14.4.4.6 FEC Rx FIFO Alarm Pointer Register FEC Tx FIFO Alarm Pointer Register

RFIFO_ALARM and TFIFO_ALARM include pointer which provide high/low level alarm information to the user integration logic and the BestComm interface. A low level alarm reports lack of data; a high level alarm reports lack of space. The alarm pointer is interpreted depending on the state of the FIFO transmit input pin: if FIFO transmit = “1”, then the alarm is represented in terms of data bytes, if FIFO Transmit = “0”, the alarm is represented in terms of free bytes. This programmable alarm can warn the system when the FIFO is almost full of data (FIFO Transmit = “0”), or when the FIFO is almost out of data (FIFO Transmit = “1”). This register is programmed to the upper limit for the number of bytes in the FIFO of data, when FIFO transmit is negated, or space, when FIFO transmit is asserted, before an internal alarm is set. Any time the amount of data or space in the FIFO is above the indicated amount, the alarm will be set. The alarm is cleared when there is less data or space than is defined as the FIFO granularity or pipeline depth. The number of bits in the alarm pointer register will vary with the address space of the FIFO memory, and the alarm pointer is initialized to zero.

Address MBAR + 0x3198, 0x31B8

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | Alarm[9:0] | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 14-26. FEC Rx/Tx FIFO Alarm Pointer Register**

**Table 14-35. FEC Rx/Tx FIFO Alarm Pointer Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:21 | — | Reserved |
| 22:31 | Alarm[9:0] | Alarm Pointer.<br>This pointer indicates the point at (or below) which to assert the FIFO alarm signal. This value is compared with data or free bytes, depending upon the state of FIFO Transmit (FIFO Transmit = “1”, alarm measures data bytes). |

### 14.4.4.7 FEC Rx FIFO Read Pointer Register FEC Tx FIFO Read Pointer Register

The RFIFO_RDPTR and TFIFO_RDPTR are a FIFO-maintained pointer which point to the next FIFO location to be read. The read pointer can be both read and written.

Address MBAR + 0x319C, 0x31BC

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | READ[9:0] | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 14-27. FEC Rx/Tx FIFO Read Pointer Register**

**Table 14-36. FEC Rx/Tx FIFO Read Pointer Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:21 | — | Reserved |
| 22:31 | READ[9:0] | Read Pointer.<br>This pointer indicates the next location to be read by the FIFO controller. |

### 14.4.4.8 FEC Rx FIFO Write Pointer Register FEC Tx FIFO Writer Pointer Register

The RFIFO_WRPTR and TFIFO_WRPTR are a FIFO-maintained pointer which point to the next FIFO location to be written. The write pointer can be both read and written.

Address MBAR + 0x31A0, 0x31C0

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | WRITE[9:0] | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 14-28. FEC Rx/Tx FIFO Write Pointer Register**

**Table 14-37. FEC Rx/Tx FIFO Write Pointer Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:21 | — | Reserved |
| 22:31 | WRITE[9:0] | WRITE Pointer.<br>This pointer indicates the next location to be written by the FIFO controller. |

### 14.4.4.9 FEC Reset Control Register

The RESET_CNTRL register allows reset of the FIFO controllers.

Address MBAR + 0x31C4

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | RCTL [1] | RCTL [0] | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 14-29. FEC Reset Control Register**

**Table 14-38. FEC Reset Control Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:5 | — | Reserved |
| 6 | RCTL[1] | 0 Do not Reset FIFO controllers.<br>1 Reset FIFO controllers. |
| 7 | RCTL[0] | 0 Disable fec_enable as a reset to FIFO controllers.<br>1 Enable fec_enable as a reset to FIFO controllers. |
| 8:31 | — | Reserved |

### 14.4.4.10 FEC Transmit FSM Register

The transmit finite state machine register (XMIT_FSM) controls operation of appending CRC. Typical use is enabled and CRC is appended.

Address MBAR + 0x31C8

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | XFSM [1] | XFSM [0] | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 14-30. FEC Transmit FSM Register**

**Table 14-39. FEC Transmit FSM Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:5 | — | Reserved |
| 6 | XFSM[1] | 0 Do not append CRC.<br>1 Append CRC (typical use). |
| 7 | XFSM[0] | 0 Disable CRC FSM.<br>1 Enable CRC FSM (typical use is enabled). |
| 8:31 | — | Reserved |

## 14.5 Initialization Sequence

This section describes which registers are hardware reset, which are reset by the FEC and what locations the user must initialize prior to enabling the FEC.

### 14.5.1 Hardware Controlled Initialization

Some registers in the FEC are reset by internal logic. Specifically those registers are control logic that generate interrupts, cause outputs to be asserted and, in general, configuration control bits.

Other registers are reset when the ETHER_EN bit is not asserted (i.e., cleared). To halt operation ETHER_EN is deasserted by either a hard reset or by software. By deasserting ETHER_EN configuration control registers such as X_CNTRL and R_CNTRL are not reset, but the entire data path is reset.

Table 14-40 shows the effect deasserting ETHER_EN has on Ethernet MAC operation and registers.

**Table 14-40. ETHER_EN De-Assertion Affect on FEC**

| Register/Machine | Reset Value |
|---|---|
| XMIT block | Transmission Aborted (bad CRC appended) |
| RECV block | Receive activity aborted |
| Tx/Rx FIFO | Reset control logic dependent on reset_cntrl |

## 14.5.2 User Initialization (Prior to Asserting ETHER_EN)

The user needs to initialize portions of the FEC prior to setting the ETHER_EN bit. The exact values depend on the particular application; the sequence of writing the registers is not important. Ethernet MAC registers requiring initialization are defined in Table 14-41.

**Table 14-41. User Initialization (Before ETHER_EN)**

| Description |
|---|
| Initialize IMASK |
| Clear IEVENT (write FFFF_FFFF) |
| X_WMRK (optional) |
| IADDR2/IADDR1 |
| GADDR1/GADDR2 |
| PADDR1/PADDR2 |
| OP_PAUSE (only needed for FDX flow control) |
| R_CNTRL |
| X_CNTRL |
| MII_SPEED (optional) |
| Clear MIB_RAM (locations 200–2FC) |

### 14.5.2.1 Microcontroller Initialization

In the FEC the descriptor control RISC initializes some registers after ETHER_EN is asserted. After the microcontroller initialization sequence is complete, hardware is ready for operation.

Table 14-42 shows RISC initialization operations common to the FEC.

**Table 14-42. Microcontroller Initialization (FEC)**

| Description |
|---|
| Initialize BackOff random number seed |
| Activate Receiver |
| Activate Transmit |

## 14.5.3 Frame Control/Status Words

In the FEC transmit frame control words and receive frame status words cross the following the end of frame data. These words are marked with a type value of 10 and have the following formats.

### 14.5.3.1 Receive Frame Status Word

Figure 14-31 below defines the format for the receive frame status word.

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 (Last) | 0 | 0 | 0 | BC | MC | LG | NO | 0 | CR | OV | TR |

| 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | FRAME_LENGTH | | | | | | | | | | |

**Figure 14-31. Receive Frame Status Word Format**

Bits 31-28, 26-25, 19 and 15-11—Reserved

**Table 14-43. Receive Frame Status Word Format Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4 | L | Last in Frame, written by the FEC<br>The buffer is not the last in a frame.<br>The buffer is the last in a frame. |
| 5:7 | | Reserved |
| 8 | BC | Will be set if the DA is broadcast (FF-FF-FF-FF-FF-FF) |
| 9 | MC | Will be set if the DA is multicast and not BC |
| 10 | LG | Rx Frame Length Violation, written by the FEC.<br>A frame length greater than R_CNTRL.MAX_FL was recognized. This bit is valid only if the L-bit is set. The receive data is not altered in any way unless the length exceeds 2047 bytes. |
| 11 | NO | Rx Non-octet Aligned Frame, written by the FEC.<br>A frame that contained a number of bits not divisible by 8 was received and the CRC check that occurred at the preceding byte boundary generated an error. This bit is valid only if the L-bit is set. If this bit is set the CR bit will not be set. |
| 12 | | Reserved |
| 13 | CR | Rx CRC Error, written by the FEC.<br>This frame contains a CRC error and is an integral number of octets in length. This bit is valid only if the L-bit is set. |
| 14 | OV | Overrun, written by the FEC.<br>A receive FIFO overrun occurred during frame reception. If this bit is set, the other status bits, M, LG, NO, SH, CR, and CL lose their normal meaning and will be zero. This bit is valid only if the L-bit is set. |
| 15 | TR | Rx Frame Truncated<br>Will be set if the receive frame is truncated (frame length > 2047 bytes). If the TR bit is set the frame should be discarded and the other error bits should be ignored as they may be incorrect. |

**Table 14-43. Receive Frame Status Word Format Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 16:20 | | Reserved |
| 21:31 | FRAME_ LENGTH | Length of Received Frame |

### 14.5.3.2 Transmit Frame Control Word

The only requirement for this control word is to have the TC and ABC bits valid. The TC bit defines whether the transmit block should append the CRC (TC = 1) or not (TC = 0) for the current frame. The ABC bit defines whether the transmit block should append a bad CRC (ABC = 1), independent of the TC value. Refer to Figure 14-32 below for the format of the transmit frame control word.

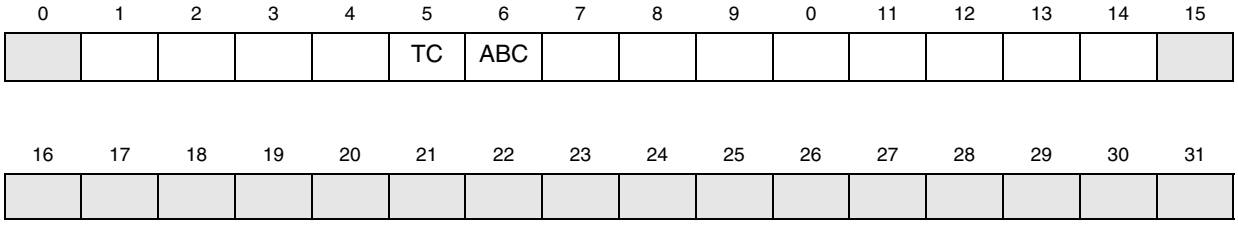



**Figure 14-32. Transmit Frame Control Word Format**

Bits 31-27, 24-0—Reserved

**Table 14-44. Transmit Frame Control Word Format Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0:4 | — | Reserved |
| 5 | TC | Transmit CRC, written by user<br>0 End transmission immediately after the last data byte.<br>1 Transmit the CRC sequence after the last data byte. |
| 6 | ABC | Append Bad CRC, written by user<br>0 No affect<br>1 Transmit the CRC sequence inverted after the last data bye (regardless of TC value). |
| 7:31 | | Reserved |

### 14.5.4 Network Interface Options

The FEC supports both an MII interface for 10/100 Mbps Ethernet and a 7-wire serial interface for 10 Mbps Ethernet. The interface mode is selected by the MII_MODE bit in the R_CNTRL register. In MII mode (R_CNTRL.MII_MODE = 1) there are 18 signals defined by the 802.3 standard and supported by the FEC. These are shown in Table 14-1.

The 7-Wire serial interface (R_CNTRL.MII_MODE = 0) operates in what is generally referred to as the "AMD" mode.

The Ethernet transmitter is designed to work with almost no intervention from software. Once ETHER_EN is asserted and data appears in the transmit FIFO the Ethernet MAC is able to transmit onto the network.

When the transmit FIFO fills to the watermark (defined by the X_WMRK register), the MAC transmit logic will assert TX_EN and start transmitting the preamble sequence, the start frame delimiter, and then the frame information from the FIFO. However, the controller defers the transmission if the network is busy (carrier sense is asserted). Before transmitting, the controller waits for carrier sense to become inactive, then determines if carrier sense stays inactive for 60 bit times. If so, then the transmission begins after waiting an additional 36 bit times (96 bit times after carrier sense originally became inactive).

If a collision occurs during transmission of the frame (half-duplex mode), the Ethernet controller follows the specified backoff procedures and attempts to retransmit the frame until the retry limit is reached. The transmit FIFO stores at least the first 64 bytes of the transmit frame, so that they do not have to be retrieved from system memory in case of a collision. This improves bus utilization and latency in case immediate retransmission is necessary.

When all the frame data has been transmitted, the FCS (32-bit CRC) bytes are appended if the TC bit is set in the transmit frame control word. If the ABC bit is set in the transmit frame control word, a bad CRC will be appended to the frame data regardless of the TC bit value. Following the transmission of the CRC, the Ethernet controller writes the frame status information to the MIB block. Short frames are automatically padded by the transmit logic (if the TC bit in the transmit buffer descriptor for the end of frame buffer = 1).

The FEC frame interrupts may be generated as determined by the settings in the IMASK register.

Transmit error interrupts are HBERR, BABT, LATE_COL, COL_RETRY_LIM, XFIFO_UN and XFIFO_ERROR. If the transmit frame length exceeds MAX_FL bytes the BABT interrupt will be asserted, however the entire frame will be transmitted (no truncation).

To pause transmission, set the GTS (Graceful Transmit Stop) bit in the X_CNTRL register. When the GTS is set the FEC transmitter stops immediately if transmission is not in progress; otherwise, it continues transmission until the current frame either finishes or terminates with a collision. After the transmitter has stopped the GRA (Graceful Stop Complete) interrupt is asserted. If GTS is cleared, the FEC resumes transmission with the next frame.

The Ethernet controller transmits bytes least significant bit first.

### 14.5.5 FEC Frame Reception

The FEC receiver is designed to work with almost no intervention from the host and can perform address recognition, CRC checking, short frame checking and maximum frame length checking.

When the driver enables the FEC receiver by asserting ETHER_EN it will immediately start processing receive frames. When RX_DV asserts, the receiver will first check for a valid PA/SFD header. If the PA/SFD is valid it will be stripped and the frame will be processed by the receiver. If a valid PA/SFD is not found the frame will be ignored.

In 7-wire serial mode, the first 16 bit times of RX_D0 following assertion of RX_DV (RENA) are ignored. Following the first 16 bit times the data sequence is checked for alternating 1s and 0s. If a 11 or 00 data sequence is detected during bit times 17 to 21, the remainder of the frame is ignored. After bit time 21, the data sequence is monitored for a valid SFD (11). If a 00 is detected, the frame is rejected. When a 11 is detected, the PA/SFD sequence is complete.

In MII mode the receiver checks for at least one byte matching the SFD. Zero or more PA bytes may occur, but if a 00 bit sequence is detected prior to the SFD byte, the frame is ignored.

After the first 6 bytes of the frame have been received, the FEC performs address recognition on the frame.

Once a collision window (64 bytes) of data has been received and if address recognition has not rejected the frame, the receive FIFO is signalled that the frame is “accepted” and may be passed on to the DMA. If the frame is a runt (due to collision) or is rejected by address recognition, the receive FIFO is notified to “reject” the frame. Thus, no collision fragments are presented to the user except late collisions, which indicate serious LAN problems.

During reception, the Ethernet controller checks for various error conditions and once the entire frame is written into the FIFO, a 32-bit frame status word is written into the FIFO. This status word contains the M, BC, MC, LG, NO, SH, CR, OV and TR status bits, and the frame length.

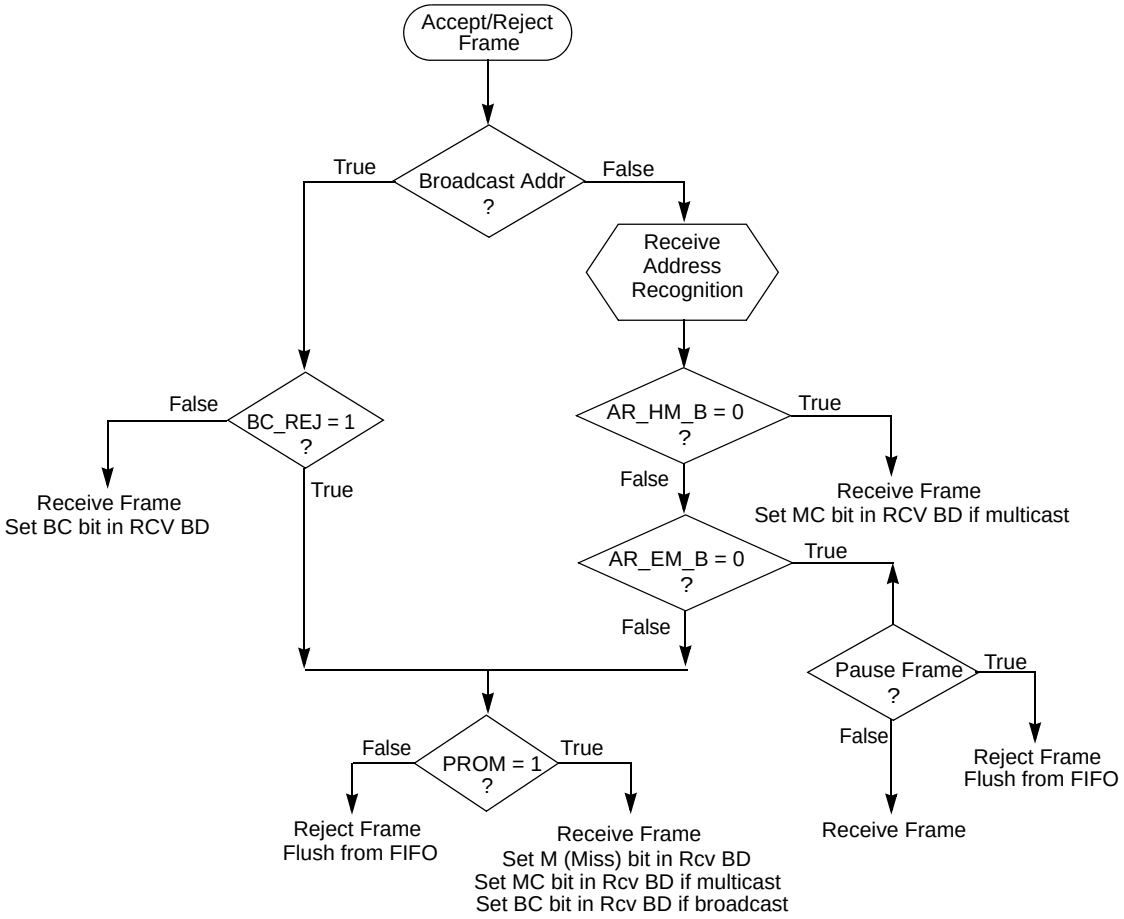
The Ethernet controller receives serial data LSB first.

### 14.5.6 Ethernet Address Recognition

The FEC filters the received frames based on destination address (DA) type — individual (unicast), group (multicast) or broadcast (all-ones group address). The difference between an individual address and a group address is determined by the I/G bit in the destination address field. A flowchart for address recognition on received frames is illustrated in the figures below.

Address recognition is accomplished through the use of the receive block and microcode running on the microcontroller. The flowchart shown in Figure 14-33 illustrates the address recognition decisions made by the receive block, while Figure 14-34 illustrates the decisions made by the microcontroller.

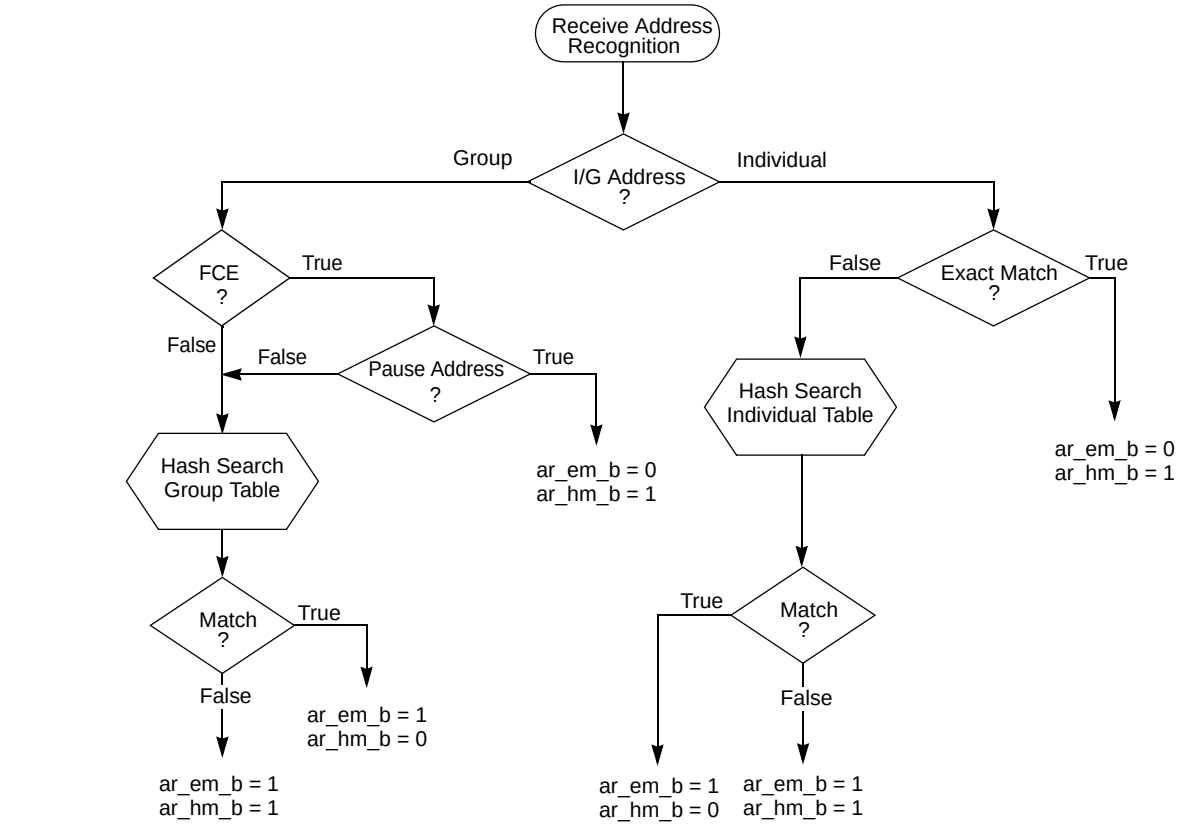
If the DA is a broadcast address and broadcast reject (R_CNTRL.BC_REJ) is deasserted, then the frame will be accepted unconditionally as shown in Figure 14-33. Otherwise, if the DA in not a broadcast address the microcontroller runs the address recognition subroutine as shown in Figure 14-34.




NOTES:
BC_REJ - field in R_CNTRL register (BroadCast REJect)
Check Address - microcode Address Recognition subroutine; returns AR_HM_B and AR_EM_B
AR_EM_B - bit in RECV.AR_DONE register (address recognition exact match bar)
AR_HM_B - bit in RECV.AR_DONE register (address recognition hash match bar)
PROM - field in R_CNTRL register (PROMiscous mode)
Pause Frame - valid PAUSE frame received

**Figure 14-33. Ethernet Address Recognition—Receive Block Decisions**

If the DA is a group (multicast) address and flow control is disabled the microcontroller will perform a group hash table lookup using the 64-entry hash table programmed in GADDR1 and GADDR2. If a hash match occurs AR_HM_B (address recognition hash match bar) is set to 0 and the receiver accepts the frame. If flow control is enabled the microcontroller will do an exact address match check between the DA and the designated PAUSE DA in registers XMIT.FDXFC_DA1 and XMIT.FDXFC_DA2. In the case where a PAUSE DA exact match occurs AR_EM_B (address recognition exact match bar) is set to 0. If the receive block determines that the received frame is a valid PAUSE frame the frame will be rejected. Note the receiver will detect a PAUSE frame with the DA field set to either the designated PAUSE DA or the unicast physical address.




NOTES:
FCE - field in R_CNTRL register (Flow Control Enable)
AR_EM_B - bit in RECV.AR_DONE register (address recognition exact match bar)
AR_HM_B - bit in RECV.AR_DONE register (address recognition hash match bar)
I/G - Individual/Group bit in Destination Address (least significant bit in first byte received in MAC frame)

**Figure 14-34. Ethernet Address Recognition—Microcode Decisions**

If the DA is the individual (unicast) address the microcontroller performs an individual exact match comparison between the DA and 48-bit physical address that the user programs in the PADDR1 and PADDR2 registers. If an exact match occurs AR_EM_B is set to 0; otherwise, the microcontroller does an individual hash table lookup using the 64-entry hash table programmed in registers IADDR1 and IADDR2. In the case of an individual hash match AR_HM_B is set to 0. Again, the receiver will accept or reject the frame based on PAUSE frame detection, shown in Figure 14-33.

If neither a hash match (group or individual) nor an exact match (group or individual) occur both AR_HM_B and AR_EM_B are set to 1. In this case, if promiscuous mode is enabled (R_CNTRL.PROM = 1), then the frame will be accepted and the MISS bit in the receive buffer descriptor is set; otherwise, the frame will be rejected and the MISS bit will be cleared.

Similarly, if the DA is a broadcast address, broadcast reject (R_CNTRL.BC_REJ) is asserted and promiscuous mode is enabled. Then the frame will be accepted and the MISS bit in the receive buffer descriptor is set; otherwise, the frame will be rejected and the MISS bit will be cleared.

In general, when a frame is rejected it is flushed from the FIFO.

The hash table algorithm used in the group and individual hash filtering operates as follows. The 48-bit destination address is mapped into one of 64 bits which are represented by 64 bits stored in GADDR1,2 (group address hash match) or IADDR1,2 (individual address hash match). This mapping is performed by passing the 48-bit address through the on-chip 32-bit CRC generator and selecting the 6 most significant bits of the CRC-encoded result to generate a number between 0 and 63. The MSB of the CRC result selects GADDR1 (MSB = 1) or GADDR2 (MSB = 0). The least significant 5 bits of the hash result select the bit within the selected register. If the CRC generator selects a bit that is set in the hash table, the frame is accepted; otherwise, it is rejected.

For example, if eight group addresses are stored in the hash table and random group addresses are received, the hash table prevents roughly 56/64 (or 87.5%) of the group address frames from reaching memory. Those that do reach memory must be further filtered by the processor to determine if they truly contain one of the eight desired addresses.

The effectiveness of the hash table declines as the number of addresses increases.

The hash table registers must be initialized by the user. The user may compute the hash for a particular address in software. The CRC32 polynomial to use in computing the hash is:

$$X^{32} + X^{26} + X^{23} + X^{22} + X^{16} + X^{12} + X^{11} + X^{10} + X^{8} + X^{7} + X^{5} + X^{4} + X^{2} + X + 1$$

A table of example Destination Addresses and corresponding hash values is included below for reference.

**Table 14-45. Destination Address to 6-Bit Hash (Sheet 1 of 3)**

| 48-Bit DA | 6-Bit Hash (in hex) | Hash Decimal Value |
|---|---|---|
| 65:ff:ff:ff:ff:ff | 0x0 | 0 |
| 55:ff:ff:ff:ff:ff | 0x1 | 1 |
| 15:ff:ff:ff:ff:ff | 0x2 | 2 |
| 35:ff:ff:ff:ff:ff | 0x3 | 3 |
| b5:ff:ff:ff:ff:ff | 0x4 | 4 |
| 95:ff:ff:ff:ff:ff | 0x5 | 5 |
| d5:ff:ff:ff:ff:ff | 0x6 | 6 |
| f5:ff:ff:ff:ff:ff | 0x7 | 7 |
| db:ff:ff:ff:ff:ff | 0x8 | 8 |
| fb:ff:ff:ff:ff:ff | 0x9 | 9 |
| bb:ff:ff:ff:ff:ff | 0xa | 10 |
| 8b:ff:ff:ff:ff:ff | 0xb | 11 |
| 0b:ff:ff:ff:ff:ff | 0xc | 12 |
| 3b:ff:ff:ff:ff:ff | 0xd | 13 |
| 7b:ff:ff:ff:ff:ff | 0xe | 14 |
| 5b:ff:ff:ff:ff:ff | 0xf | 15 |
| 27:ff:ff:ff:ff:ff | 0x10 | 16 |
| 07:ff:ff:ff:ff:ff | 0x11 | 17 |
| 57:ff:ff:ff:ff:ff | 0x12 | 18 |
| 77:ff:ff:ff:ff:ff | 0x13 | 19 |

**Table 14-45. Destination Address to 6-Bit Hash (Sheet 2 of 3)**

| 48-Bit DA | 6-Bit Hash (in hex) | Hash Decimal Value |
|---|---|---|
| f7:ff:ff:ff:ff:ff | 0x14 | 20 |
| c7:ff:ff:ff:ff:ff | 0x15 | 21 |
| 97:ff:ff:ff:ff:ff | 0x16 | 22 |
| a7:ff:ff:ff:ff:ff | 0x17 | 23 |
| 99:ff:ff:ff:ff:ff | 0x18 | 24 |
| b9:ff:ff:ff:ff:ff | 0x19 | 25 |
| f9:ff:ff:ff:ff:ff | 0x1a | 26 |
| c9:ff:ff:ff:ff:ff | 0x1b | 27 |
| 59:ff:ff:ff:ff:ff | 0x1c | 28 |
| 79:ff:ff:ff:ff:ff | 0x1d | 29 |
| 29:ff:ff:ff:ff:ff | 0x1e | 30 |
| 19:ff:ff:ff:ff:ff | 0x1f | 31 |
| d1:ff:ff:ff:ff:ff | 0x20 | 32 |
| f1:ff:ff:ff:ff:ff | 0x21 | 33 |
| b1:ff:ff:ff:ff:ff | 0x22 | 34 |
| 91:ff:ff:ff:ff:ff | 0x23 | 35 |
| 11:ff:ff:ff:ff:ff | 0x24 | 36 |
| 31:ff:ff:ff:ff:ff | 0x25 | 37 |
| 71:ff:ff:ff:ff:ff | 0x26 | 38 |
| 51:ff:ff:ff:ff:ff | 0x27 | 39 |
| 7f:ff:ff:ff:ff:ff | 0x28 | 40 |
| 4f:ff:ff:ff:ff:ff | 0x29 | 41 |
| 1f:ff:ff:ff:ff:ff | 0x2a | 42 |
| 3f:ff:ff:ff:ff:ff | 0x2b | 43 |
| bf:ff:ff:ff:ff:ff | 0x2c | 44 |
| 9f:ff:ff:ff:ff:ff | 0x2d | 45 |
| df:ff:ff:ff:ff:ff | 0x2e | 46 |
| ef:ff:ff:ff:ff:ff | 0x2f | 47 |
| 93:ff:ff:ff:ff:ff | 0x30 | 48 |
| b3:ff:ff:ff:ff:ff | 0x31 | 49 |
| f3:ff:ff:ff:ff:ff | 0x32 | 50 |
| d3:ff:ff:ff:ff:ff | 0x33 | 51 |
| 53:ff:ff:ff:ff:ff | 0x34 | 52 |
| 73:ff:ff:ff:ff:ff | 0x35 | 53 |
| 23:ff:ff:ff:ff:ff | 0x36 | 54 |
| 13:ff:ff:ff:ff:ff | 0x37 | 55 |
| 3d:ff:ff:ff:ff:ff | 0x38 | 56 |
| 0d:ff:ff:ff:ff:ff | 0x39 | 57 |
| 5d:ff:ff:ff:ff:ff | 0x3a | 58 |
| 7d:ff:ff:ff:ff:ff | 0x3b | 59 |

**Table 14-45. Destination Address to 6-Bit Hash (Sheet 3 of 3)**

| 48-Bit DA | 6-Bit Hash (in hex) | Hash Decimal Value |
|---|---|---|
| fd:ff:ff:ff:ff:ff | 0x3c | 60 |
| dd:ff:ff:ff:ff:ff | 0x3d | 61 |
| 9d:ff:ff:ff:ff:ff | 0x3e | 62 |
| bd:ff:ff:ff:ff:ff | 0x3f | 63 |

## 14.5.7 Full-Duplex Flow Control

Full-duplex flow control allows the user to transmit pause frames and to detect received pause frames. Upon detection of a pause frame, MAC data frame transmission stops for a given pause duration.

To enable pause frame detection, the FEC must operate in full-duplex mode (X_CNTRL.FDEN asserted) and flow control enable (R_CNTRL.FCE) must be asserted. The FEC detects a pause frame when the fields of the incoming frame match the pause frame specifications as shown in the table below. In addition, the receive status associated with the frame should indicate that the frame is valid

**Table 14-46. PAUSE Frame Field Specification**

| 48-Bit Destination Address | 0180_c200_0001 or Physical Address |
|---|---|
| 48-bit Source Address | any |
| 16-bit type | 8808 |
| 16-bit opcode | 0001 |
| 16-bit PAUSE duration | 0000 to ffff |

Pause frame detection is performed by the receiver and microcontroller modules. The microcontroller runs an address recognition subroutine to detect the specified pause frame destination address, while the receiver detects the type and opcode pause frame fields. On detection of a pause frame, graceful transmit stop is asserted by the FEC internally. When transmission has paused, the GRA (Graceful Stop complete) interrupt is asserted and the pause timer begins to increment. Note that the pause timer makes use of the transmit backoff timer hardware which is used for tracking the appropriate collision backoff time in half-duplex mode. The pause timer increments once every slot time until PAUSE_DURATION slot times have expired. On PAUSE_DURATION expiration, graceful transmit stop is deasserted allowing MAC data frame transmission to resume. Note that the receive flow control pause (X_CNTRL.RFC_PAUSE) status bit is asserted while the transmitter is paused due to reception of a pause frame.

To transmit a pause frame the FEC must operate in full-duplex mode and the user must assert flow control pause (X_CNTRL.TFC_PAUSE). On assertion of transmit flow control pause (X_CNTRL.TFC_PAUSE) the transmitter asserts graceful transmit stop internally. When the transmission of data frames stops the GRA (Graceful Stop complete) interrupt asserts. Following GRA assertion the Pause frame is transmitted. On completion of pause frame transmission flow control pause (X_CNTRL.TFC_PAUSE) and graceful transmit stop are deasserted internally.

During pause frame transmission the transmit hardware places data into the transmit data stream from the registers shown in the table below.

**Table 14-47. Transmit Pause Frame Registers**

| PAUSE FRame Fields | FEC Register | Register Contents |
|---|---|---|
| 48-bit destination address | {FDXFC_DA1[0:31], FDXFC_DA2[0:15]} | 0180_c200_0001 |
| 48-bit Source Address | {PADDR1[0:31], PADDR2[0:15]} | physical address |
| 16-bit type | PADDR2[16:31] | 8808 |
| 16-bit opcode | OP_PAUSE[0:15] | 0001 |
| 16-bit PAUSE duration | OP_PAUSE[16:31] | 0000 to ffff |

The user must specify the desired pause duration in the OP_PAUSE register.

Note that when the transmitter is paused due to receiver/microcontroller pause frame detection, transmit flow control pause (X_CNTRL.TFC_PAUSE) still may be asserted and will cause the transmission of a single pause frame. In this case the GRA interrupt will not be asserted.

## 14.5.8 Inter-Packet Gap Time

The minimum inter packet gap time for back-to-back transmission is 96 bit times. After completing a transmission or after the backoff algorithm completes the transmitter waits for carrier sense to be negated before starting its 96 bit time IPG counter. Frame transmission may begin 96 bit times after carrier sense is negated if it stays negated for at least 60 bit times. If carrier sense asserts during the last 36 bit times it will be ignored and a collision will occur.

The receiver receives back-to-back frames with a minimum spacing of at least 28 bit times. If an inter-packet gap between receive frames is less than 28 bit times the following frame may be discarded by the receiver.

## 14.5.9 Collision Handling

If a collision occurs during frame transmission the Ethernet controller will continue the transmission for at least 32 bit times, transmitting a JAM pattern consisting of 32 one’s. If the collision occurs during the preamble sequence the JAM pattern will be sent after the end of the preamble sequence.

If a collision occurs within 64 byte times the retry process is initiated. The transmitter waits a random number of slot times. A slot time is 512 bit times. If a collision occurs after 64 byte times no retransmission is performed and the end of frame buffer is closed with an LC error indication.

## 14.5.10 Internal and External Loopback

Both internal and external loopback are supported by the Ethernet controller. In loopback mode both of the FIFOs are used and the FEC actually operates in a full-duplex fashion. Both internal and external loopback are configured using combinations of the LOOP and DRT bits in the R_CNTRL register and the FDEN bit in the X_CNTRL register.

For both internal and external loopback set FDEN = 1.

For internal loopback set LOOP = 1 and DRT = 0. TX_EN and TX_ER will not assert during internal loopback. During internal loopback the transmit/receive data rate is higher than in normal operation because the internal system clock is used by the transmit and receive blocks instead of the clocks from the external transceiver. This will cause an increase in the required system bus bandwidth for transmit and receive data being transferred to/from external memory. It may be necessary to pace the frames on the transmit side and/or limit the size of the frames to prevent transmit FIFO underrun and receive FIFO overflow.

For external loopback set LOOP = 0, DRT = 0 and configure the external transceiver for loopback.

## 14.5.11 Ethernet Error-Handling Procedure

The Ethernet controller reports frame reception and transmission error conditions using the FEC BDs (receive), the IEVENT register and the MIB block counters.

### 14.5.11.1 Transmission Errors

**Transmitter Underrun —** If this error occurs the FEC sends 32 bits that ensure a CRC error and stops transmitting. All remaining buffers for that frame are then flushed and closed. The UN bit is set in the X_STATUS register. The FEC will then continue to the next transmit buffer descriptor and begin transmitting the next frame.

The XFIFO_UN interrupt will be asserted if enabled in the IMASK register.

**Carrier Sense Lost During Frame Transmission —** When this error occurs and no collision is detected in the frame the FEC sets the CSL bit in X_STATUS register. The frame is transmitted normally. No retries are performed as a result of this error.

No interrupt is generated as a result of this error.

**Retransmission Attempts Limit Expired** — When this error occurs the FEC terminates transmission. All remaining buffers for that frame are then flushed and closed and the RL bit is set in the X_STATUS register. The FEC will then continue to the next transmit buffer descriptor and begin transmitting the next frame.

The COL_RETRY_LIM interrupt will be asserted if enabled in the IMASK register.

**Late Collision** — When a collision occurs after the slot time (512 bits starting at the Preamble), the FEC terminates transmission. All remaining buffers for that frame are then flushed and closed and the LC bit is set in the X_STATUS register. The FEC will then continue to the next transmit buffer descriptor and begin transmitting the next frame.

The LATE_COL interrupt will be asserted if enabled in the IMASK register.

**Heartbeat** — Some transceivers have a self-test feature called “heartbeat” or “signal quality error.” To signify a good self-test the transceiver indicates a collision to the FEC within 20 clocks after completion of a frame transmitted by the Ethernet controller. This indication of a collision does not imply a real collision error on the network but is rather an indication that the transceiver still seems to be functioning properly. This is called the heartbeat condition.

If the HBC bit is set in the X_CNTRL register and the heartbeat condition is not detected by the **FEC** after a frame transmission a heartbeat error occurs. When this error occurs the FEC closes the buffer, sets the HB bit in the X_STATUS register and generates the HBERR interrupt if it is enabled.

### 14.5.11.2 Reception Errors

**Overrun Error —** If the receive block has data to put into the receive FIFO and the receive FIFO is full, the FEC sets the OV bit in the receive status word. All subsequent data in the frame will be discarded and subsequent frames may also be discarded until the receive FIFO is serviced by the DMA and space is made available. At this point the receive frame/status word is written into the FIFO with the OV bit is set. This frame must be discarded by the driver.

**Non-Octet Error (Dribbling Bits)** — The Ethernet controller handles up to seven dribbling bits when the receive frame terminates nonoctet aligned and it checks the CRC of the frame on the last octet boundary. If there is a CRC error, then the frame nonoctet aligned (NO) error is reported in the Receive Frame Status Word. If there is no CRC error, then no error is reported.

**CRC Error** — When a CRC error occurs with no dribble bits, the FEC closes the buffer and sets the CR bit in the Receive Frame Status Word. CRC checking cannot be disabled, but the CRC error can be ignored if checking is not required.

**Frame Length Violation** — When the receive frame length exceeds MAX_FL bytes the BABR interrupt will be generated and the LG bit in the end of frame Receive Frame Status Word will be set. The frame is not truncated (truncation occurs if the frame length exceeds 2047 bytes).

**Truncation** — When the receive frame length exceeds 2047 bytes the frame is truncated and the TR bit is set in the receive BD.

**NOTE**

There is an issue with receive buffer overrum errors and data size errors. When an incoming packet does not have “line alignment,” there is a possibility that the FEC will write two lines of data to memory. There is also an issue with data size error where a descriptor indicates a data length greater than the programmed maximum packet size.

The FEC must work in conjunction with the BestComm controller. Both of these problems are solved using BestComm API 2.2 or later.

# Chapter 15
# Programmable Serial Controller (PSC)

## 15.1 Overview

The following sections are contained in this document:

- Section 15.2, “Memory Map and Register Definitions”
- Section 15.3, “PSC Operation Modes”
- Section 15.4, “PSC FIFO System”

The MPC5200 has these independent Programmable Serial Controllers (PSCs):

- PSC1 = MBAR + 0x2000
- PSC2 = MBAR + 0x2200
- PSC3 = MBAR + 0x2400
- PSC4 = MBAR + 0x2600
- PSC5 = MBAR + 0x2800
- PSC6 = MBAR + 0x2C00

The internal configuration registers and the functional behavioral is equal for all PSC modules. Because of a pinout limitation, not all functions are available for all PSCs on every port. Table 15-1 shows which PSC supports which mode.

**Table 15-1. PSC Mode Overview**

| | PSC1 | PSC2 | PSC3 | PSC4 | PSC5 | PSC6 |
|---|---|---|---|---|---|---|
| UART | Yes | Yes | Yes | Yes | Yes | Yes |
| Modem / SPI / $I^2S$ / ESAI | Yes | Yes | Yes | No | No | Yes |
| Mclk Generation output | Yes | Yes | Yes | No | No | No |
| AC97 | Yes | Yes | No | No | No | No |
| IrDA | No | No | No | No | No | Yes |
| Cell Phone | Master | Slave | slave | No | No | Slave |

Each PSC can be clocked by an internal clock source or an external clock source. Figure 15-1 shows a simplified PSC block diagram. In addition, each PSC module interfaces directly to the CPU and consists of the following:

- Serial Communication Channel
- Programmable Transmit (Tx) Receive (Rx) Clock Generation
- Internal Channel Control Logic
- Interrupt Control Logic
- FIFO System

In addition the PSC provide an Mclk for the external Codec, eliminating the need for an external crystal for the external device. For more information about the Codec mode see Section 15.3.2, "PSC in Codec Mode."

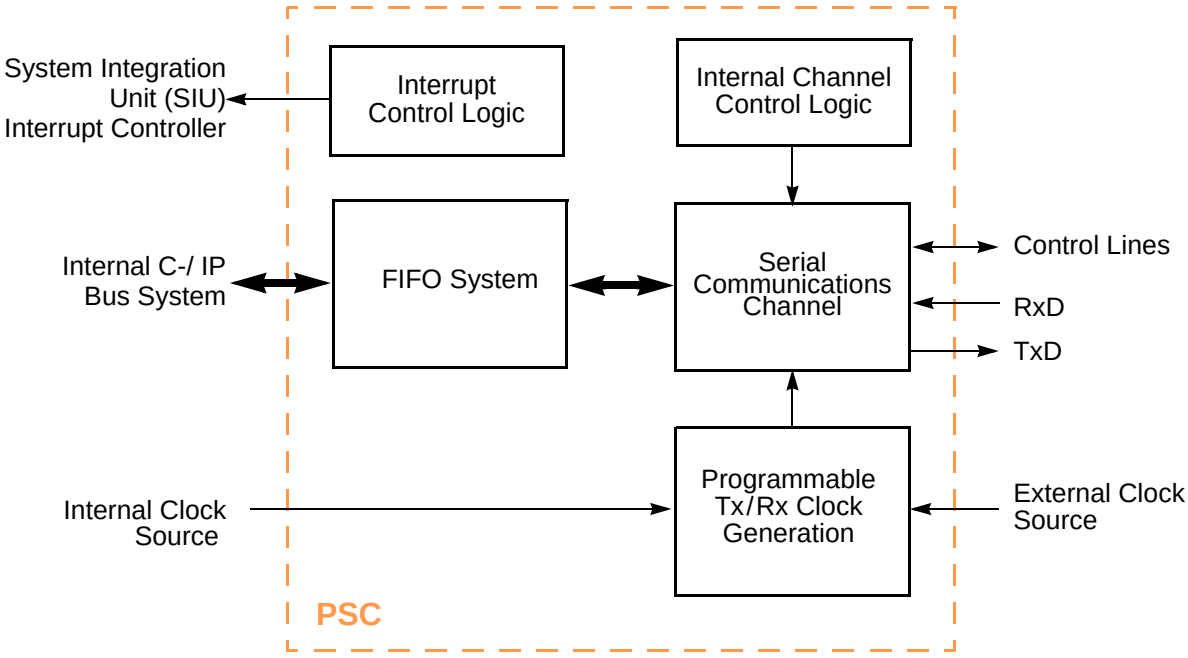



**Figure 15-1. Block Diagram**

### 15.1.1 PSC Functions Overview

The PSC module of the MPC5200 provide different groups of interfaces to connect the MPC5200 to other devices. Figure 15-2.shows the groups of interfaces:

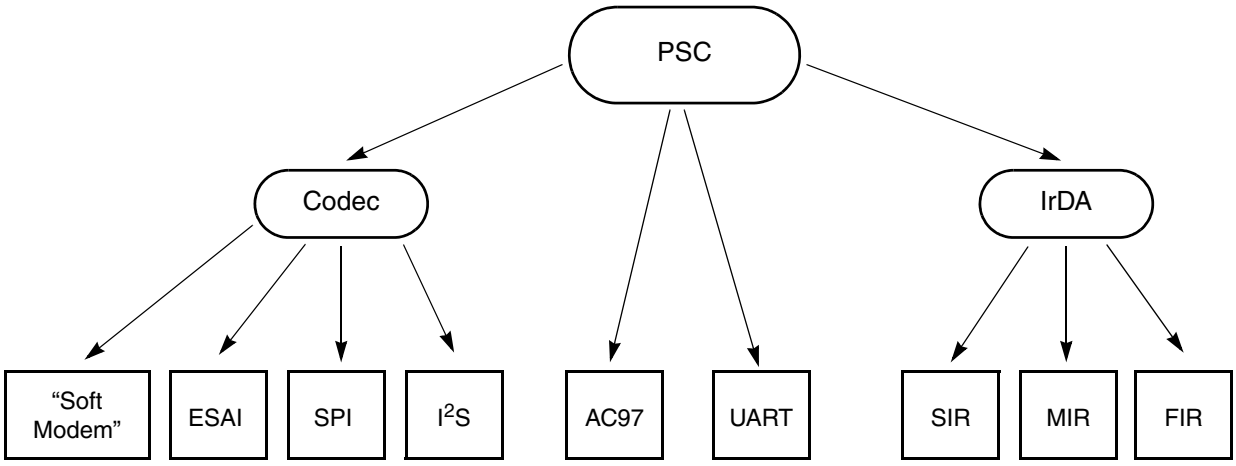



**Figure 15-2. PSC Functions Overview**

1. PSC Codec Mode: In this section, the name Codec mode is used as a collective term for the "normal soft Modem" the SPI, $I^2S$, and ESAI mode. This interfaces are provide by one internal block of the PSC. The interface consist of serial TX and RX lines, a bit clock line and a FrameSync signal. For these modes the clock configuration is similar and use the same configuration registers. The transmitter converts the parallel data from the CPU to a serial bit-stream, the receiver converts the serial data from the RX line to parallel data. The PSCs support Codec mode with 8, 16, 24 and 32 bit data width, with active high or active low FrameSync signal and with programmable bit clock polarity. All Codec modes can work as an Codec master (PSC dive the bit clock and FrameSync signals) or as a Codec Slave (PSC receive the bit clock and frame sync signal). For more information about the Codec mode see Section 15.3.2, "PSC in Codec Mode."
2. AC97 Mode: When programmed as AC97, the PSC works as an AC97 Controller, it's means that the PSC receive the BitClk from the external AC97 Codec and provide the FrameSync signal to the external Codec. Only PSC1 and PSC2 support the AC97 functionality. In the legacy AC97 mode, the data words for all AC97 slots must be in the TX FIFO including the slot 0,1 and slot 2data. The PSC is not able to modify the control slot data. Also all data words from the RX line will be in the FIFO. Only if the PSC detect a "codec not ready" status the PSC will stop sending and receiving data. In the normal AC97 mode, only the data slots must be in the FIFO. The PSC generate the slot0, slot1, and slot2 values depend on data to send. In both AC97 modes the PSC reads only 32 bits from the FIFO. For more information about the AC97 mode, see Section 15.3.3, "PSC in AC97 Mode."
3. PSC UART Mode: When programmed as a UART, the PSC serial communication channel provides a full-duplex asynchronous receiver and transmitter deriving an operating frequency from an internal clock. The transmitter converts parallel data from the CPU to a serial bit-stream, inserting appropriate start, stop, and parity bits. It outputs the resulting stream on the channel transmitter serial data output (TxD). The receiver converts serial data from the channel receiver serial data input (RxD) to parallel format, checks for start, stop, and parity bits, or line break

conditions, and transfers the assembled character onto the bus during read operations. The receiver may be poll-driven or interrupt-driven. For more information about the UART mode see Section 15.3.1, “PSC in UART Mode.”

4. PSC IrDA Mode: When programmed as an IrDA interface, the PSC provides an full-duplex asynchronous communication which is optimized for Infrared transmission. The in this configuration the SIR, MIR and FIR modes are supported. The transmitter converts the parallel data from the CPU to a serial bit-stream and add some control characters, the receiver checks the control characters and converts the serial data from the RX line to parallel data. For more information about the UART mode see Section 15.3.4, “PSC in IrDA Mode.”

## 15.1.2 Features

General Features:

- 512-byte receiver (Rx) FIFO
- 512-byte transmitter (Tx) FIFO
- Each channel is programmable to normal (full-duplex), automatic echo, local loop-back, or remote loop-back mode
- Automatic Wake-up mode for multidrop applications
- 6 maskable interrupt conditions
- PSC Tx and Rx FIFOs can be programmed to interrupt either the BestComm or the CPU when they require filling or emptying, respectively.

PSC UART Mode:

- Each is clocked by an internal clock source (IPB clock), eliminating the need for an external crystal
- Full-duplex asynchronous receiver/transmitter channel
- Programmable data format:
  - Five to eight data bits plus parity
  - Odd, even, no parity, or force parity
  - One, one-and-a-half, or two STOP bits
- Parity, framing, and overrun error detection
- False-start bit detection
- Line-break detection and generation
- Detection of breaks originating in the middle of a character
- Start/end break interrupt/status

PSC Codec Mode:

- Programmable to interface to an 8-, 16-, 24-, or 32-bit Codec for “soft modem” support
- Support master mode, driving clock and FrameSync signals
- Support slave mode, receiving clock and the FrameSync from the external Codec
- Supports full duplex SPI interface
- Supports $I^2S$ interface

- No parity error, framing error, or line break detection in Codec mode
- Ability to generate a master clock (Mclk) for an external Codec device, independent from the mode (master or slave)
- Programmable width of the FrameSync signal
- FrameSync and bit clock frequencies are independently programmable
- Frame sync and bit clock polarity are programmable
- Support “digital cell phone” interface

AC97 Mode:

- PSC1 and PSC2 support an AC97 interface
- Support “normal” and “legacy” mode

IrDA SIR Mode:

- Baud rate: 2400 to 115200 bps
- Selectable pulse width: either 3/16 bit duration or 1.6 µs

IrDA MIR Mode:

- Baud rate: 0.576 Mbps to 1.152 Mbps

IrDA FIR Mode:

- Baud rate: 4 Mbps

## 15.2 Memory Map and Register Definitions

The PSCs are located at an address as indicated below:

- PSC1 BASE = MBAR + 0x2000
- PSC2 BASE = MBAR + 0x2200
- PSC3 BASE = MBAR + 0x2400
- PSC4 BASE = MBAR + 0x2600
- PSC5 BASE = MBAR + 0x2800
- PSC6 BASE = MBAR + 0x2C00

Each PSC uses 42 registers. The register address is calculated as base address for the regarding PSC plus the offset value. Table 15-2 shows the list with all implemented registers and the associated offset value.

## 15.2.1 Memory Map

**Table 15-2. PSC Memory Map**

| Offset | Register Name | Register Width | Access |
|---|---|---|---|
| 00 | Mode Register 1 (MR1) | 8 | R/W |
| 00 | Mode Register 2 (MR2) | 8 | R/W |
| 04 | Status Register (SR) | 16 | R |
| 04 | Clock Select Register (CSR) | 16 | W |
| 08 | Command Register (CR) | 8 | R/W |
| 0C | Rx Buffer Register (RB) | 32 | R |
| 0C | Tx Buffer Register (TB) | 32 | W |
| 10 | Input Port Change Register (IPCR) | 8 | R |
| 10 | Auxiliary Control Register (ACR) | 8 | W |
| 14 | Interrupt Status Register (ISR) | 16 | R |
| 14 | Interrupt Mask Register (IMR) | 16 | W |
| 18 | Counter Timer Upper Register (CTUR) | 8 | W |
| 1C | Counter Timer Lower Register (CTLR) | 8 | W |
| 20 | Codec Clock Register (CCR) | 32 | R/W |
| 24 | AC97 Slots Register (AC97Slots) | 32 | W |
| 28 | AC97 Command Register (AC97CMD) | 32 | R/W |
| 2C | AC97 Status Data Register (AC97Data) | 32 | R |
| 30 | Interrupt Vector Register (IVR) - Reserved | 8 | R/W |
| 34 | Input Port Register (IP) | 8 | R |
| 38 | Output Port 1 Bit Set (OP1) | 8 | W |
| 3C | Output Port 0 Bit Set (OP0) | 8 | W |
| 40 | Serial Interface Control Register (SICR) | 32 | R/W |
| 44 | Infrared Control 1 (IRCR1) | 8 | R/W |
| 48 | Infrared Control 2 (IRCR2) | 8 | R/W |
| 4C | Infrared SIR Divide Register (IRSDR) | 8 | R/W |
| 50 | Infrared MIR Divide Register (IRMDR) | 8 | R/W |
| 54 | Infrared FIR Divide Register (IRFDR) | 8 | R/W |
| 58 | Rx FIFO Number of Data (RFNUM) | 16 | R |
| 5C | Tx FIFO Number of Data (TFNUM) | 16 | R |
| 60 | Rx FIFO Data (RFDATA) | 32 | R/W |
| 64 | Rx FIFO Status (RFSTAT) | 16 | R/W |
| 68 | Rx FIFO Control (RFCNTL) | 8 | R/W |
| 6E | Rx FIFO Alarm (RFALARM) | 16 | R/W |
| 72 | Rx FIFO Read Pointer (RFRPTR) | 16 | R/W |
| 76 | Rx FIFO Write Pointer (RFWPTR) | 16 | R/W |
| 7A | Rx FIFO Last Read Frame (RFLRFPTR) - Reserved | 16 | R/W |
| 7C | Rx FIFO Last Write Frame PTR (RFLWFPTR) - Reserved | 16 | R/W |

**Table 15-2. PSC Memory Map (continued)**

| Offset | Register Name | Register Width | Access |
|---|---|---|---|
| 80 | Tx FIFO Data (TFDATA) | 32 | R/W |
| 84 | Tx FIFO Status (TFSTAT) | 16 | R/W |
| 88 | Tx FIFO Control (TFCNTL) | 8 | R/W |
| 8E | Tx FIFO Alarm (TFALARM) | 16 | R/W |
| 92 | Tx FIFO Read Pointer (TFRPTR) | 16 | R/W |
| 96 | Tx FIFO Write Pointer (TFWPTR) | 16 | R/W |
| 9A | Tx FIFO Last Read Frame (TFLRFPTR) - Reserved | 16 | R/W |
| 9C | Tx FIFO Last Write Frame PTR (TFLWFPTR) - Reserved | 16 | R/W |

PSC module operation is controlled by writing control bytes into the appropriate registers.

## 15.2.2 Register Descriptions

### 15.2.2.1 Mode Register 1 (MR1)

The Mode registers (MR1) control configuration. MR1 can be read or written when the Mode register pointer points to it, at reset or after a reset Mode register pointer command using CR[MISC]. After MR1 is read or written, the pointer points to MR2.

Address MBAR + 0x00

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | RxRTS | RxIRQ/<br>FFULL | Reserved | PM | | PT | B/C | |
| Reset | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-3. Mode Register 1 for UART Mode**

Address MBAR + 0x00

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | RxRTS | RxIRQ/<br>FFULL | Reserved | | | | | |
| Reset | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |

**Figure 15-4. Mode Register 1 for SIR Mode**

Address MBAR + 0x00

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | RxIRQ/<br>FFULL | Reserved | | | | | |
| Reset | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |

**Table 15-3. Mode Register 1 for Other Modes**

**Table 15-4. Mode Register 1 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | RxRTS | **UART / SIR**—Receiver request-to-send—Allows $\overline{\text{RTS}}$ output to control the $\overline{\text{CTS}}$ input of the transmitting device to prevent receiver overrun. If both the receiver and transmitter are incorrectly programmed for $\overline{\text{RTS}}$ control, $\overline{\text{RTS}}$ control is disabled for both. Transmitter RTS control is configured in MR2[TxRTS]. Not used in Codec mode.<br>0 Receiver has no effect on $\overline{\text{RTS}}$.<br>1 When a valid start bit is received, $\overline{\text{RTS}}$ is negated if the PSC FIFO is full. $\overline{\text{RTS}}$ is reasserted when the FIFO has an empty position available.<br>**Other Modes**—Reserved |
| 1 | RxIRQ/FFULL | Receiver interrupt select.<br>0 RxRDY is the source that generates IRQ<br>1 FFULL is the source that generates IRQ. |
| 2 | — | Reserved |
| 3:4 | PM | **UART**—Parity mode—Selects the parity or multidrop mode for the channel. The parity bit is added to the transmitted character, and the receiver performs a parity check on incoming data. The value of PM affects PT, as shown Table 15-5. PM is not used in Codec mode.<br>**Other Modes**—Reserved |
| 5 | PT | **UART**—Parity Type—PM and PT together select parity type (PM = 0x) or determine whether a data or address character is transmitted (PM = 11). PT is not used in Codec mode. See Table 15-5.<br>**Other Modes**—Reserved |
| 6:7 | B/C | **UART**—Bits per Character—Select the number of data bits per character to be sent. The values shown do not include start, parity, or stop bits. B/C is not used in Codec mode.<br>00 5 bits<br>01 6 bits<br>10 7 bits<br>11 8 bits<br>**Other Modes**—Reserved |

**Table 15-5. Parity Mode/Parity Type Definitions**

| PM | Parity Mode | Parity Type (PT=0) | Parity Type (PT=1) |
|---|---|---|---|
| 00 | With parity | Even parity | Odd parity |
| 01 | Force parity | Low parity | High parity |
| 10 | No parity | n/a | |
| 11 | Multidrop mode | Data character | Address character |

### 15.2.2.2 Mode Register 2 (MR2)

Mode register 2 (MR2) can be read or written when the Mode register pointer points to it, which occurs after any access to MR1. An MR2 access does not update the mode register address.

Address MBAR + 0x00

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | CM | | TxRTS | TxCTS | SB | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-5. Mode Register 2 for UART / SIR Mode**

Address MBAR + 0x00

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | CM | | Reserved | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-6. Mode Register 2 for Other Modes**

**Table 15-6. Mode Register 2 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | CM | Channel mode—Selects a channel mode.CM is used in both UART and Codec modes.<br>00 Normal<br>01 Automatic echo<br>10 Local loop-back<br>11 Remote loop-back |
| 2 | TxRTS | **UART / SIR**—Transmitter ready-to-send—Controls negation of $\overline{\text{RTS}}$ to automatically terminate a message transmission. Attempting to program a receiver and transmitter in the same channel for $\overline{\text{RTS}}$ control is not permitted and disables $\overline{\text{RTS}}$ control for both. TxRTS is not used in Codec mode.<br>0 The transmitter has no effect on $\overline{\text{RTS}}$.<br>1 In applications where the transmitter is disabled during the last byte transmission is running (TX FIFO is empty), setting this bit automatically clears RTS line one bit-time after any characters in the transmitter shift registers are completely sent, including the programmed number of stop bits.<br>**Other Modes**—Reserved |
| 3 | TxCTS | **UART / SIR**—Transmitter clear-to-send—If both TxCTS and TxRTS are enabled, TxCTS controls the operation of the transmitter. TxCTS is not used in Codec mode.<br>0 $\overline{\text{CTS}}$ has no effect on the transmitter.<br>1 Enables clear-to-send operation. The transmitter checks the state of $\overline{\text{CTS}}$ each time it is ready to send a character.<br>If $\overline{\text{CTS}}$ is asserted, the character is sent<br>If it is negated, the channel TxD remains in a high state and transmission is delayed until $\overline{\text{CTS}}$ is asserted.<br>Changes in $\overline{\text{CTS}}$ as a character is being sent do not affect its transmission.<br>**Other Modes**—Reserved |
| 4:7 | SB | **UART**—Stop-Bit (length control)—Selects the stop bit length that is appended to the transmitted character. Stop-bit lengths of 9/16th to 2 bits are programmable for 6-, 8-bit characters. Lengths of 1 1/16th to 2 bits are programmable for 5-bit characters. In all cases, the receiver checks only for a high condition at the center of the first stop-bit position, that is, one bit-time after the last data bit or after the parity bit, if parity is enabled. Therefore the receiver doesn't support a stop bit length less than one. Not used in Codec mode, see Table 15-7.<br>**Other Modes**—Reserved |

**Table 15-7. Stop-Bit Lengths**

| SB | 5 Bits | 6–8 Bits | SB | 5 Bits | 6–8 Bits | SB | 5–8 Bits | SB | 5–8 Bits |
|---|---|---|---|---|---|---|---|---|---|
| 0000 | 1.063 | 0.563 | 0100 | 1.313 | 0.813 | 1000 | 1.563 | 1100 | 1.813 |
| 0001 | 1.125 | 0.625 | 0101 | 1.375 | 0.875 | 1001 | 1.625 | 1101 | 1.875 |
| 0010 | 1.188 | 0.688 | 0110 | 1.438 | 0.938 | 1010 | 1.688 | 1110 | 1.938 |
| 0011 | 1.250 | 0.750 | 0111 | 1.500 | 1.000 | 1011 | 1.750 | 1111 | 2.000 |

### 15.2.2.3 Status Register (SR)

The read-only SR register shows status of the transmitter, the receiver, and the FIFO.

Address MBAR + 0x04

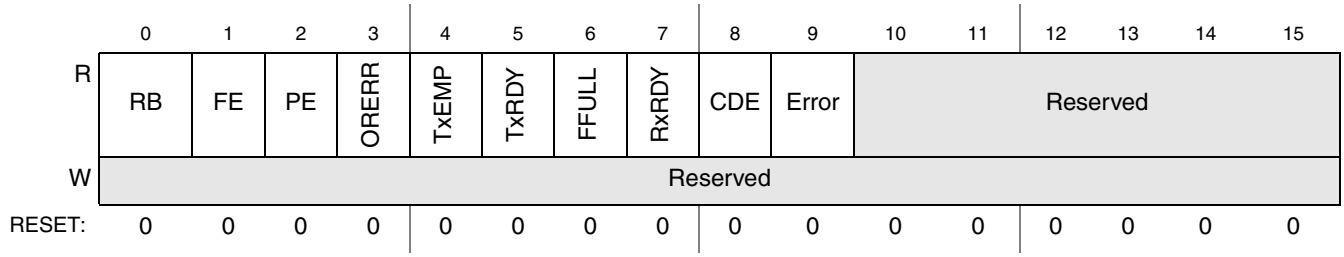

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
R
RB FE PE ORERR TxEMP TxRDY FFULL RxRDY CDE Error Reserved
W
Reserved
RESET:
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

**Figure 15-7. Status Register for UART Mode**

Address MBAR + 0x04

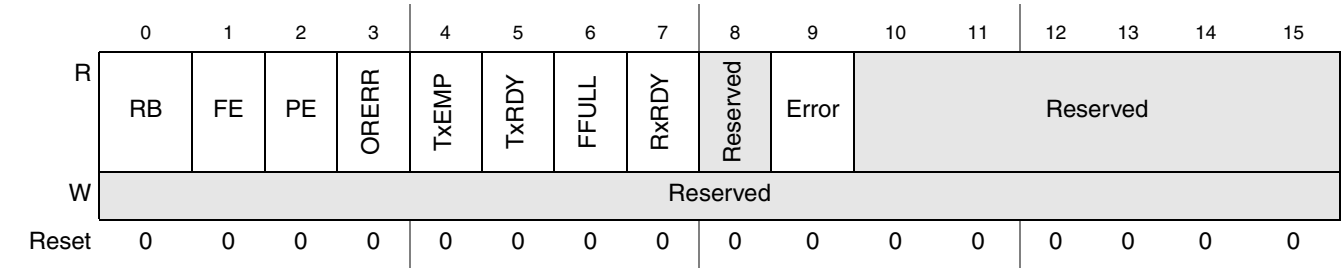

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
R
RB FE PE ORERR TxEMP TxRDY FFULL RxRDY Reserved Error Reserved
W
Reserved
Reset
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

**Figure 15-8. Status Register for SIR Mode**

Address MBAR + 0x04

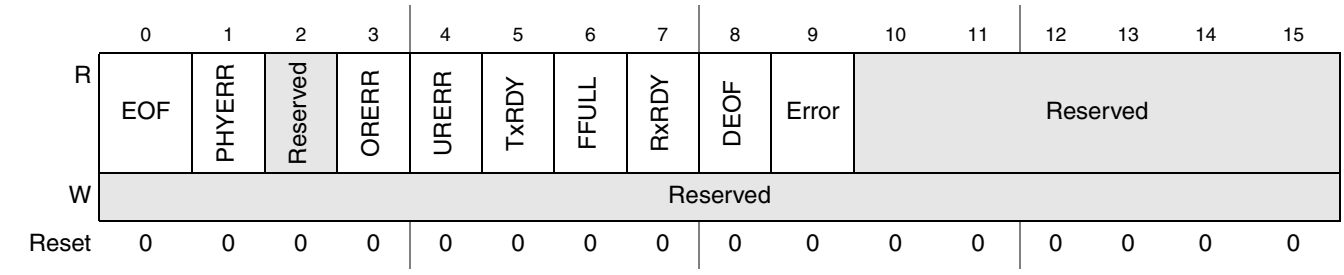

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
R
EOF PHYERR Reserved ORERR URERR TxRDY FFULL RxRDY DEOF Error Reserved
W
Reserved
Reset
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

**Figure 15-9. Status Register for MIR / FIR Mode**

Address MBAR + 0x04

**Figure 15-10. Status Register for other Modes**

**Table 15-8. Status Register Field Descriptions (Sheet 1 of 3)**

| Bit | Name | Description |
|---|---|---|
| 0 | RB/<br>EOF | **UART / SIR** —Received Break—detects breaks originating in middle of received character. Such a break must persist until the end of next detected character time.<br>0 No break received.<br>1 An all-0 character of the programmed length was received without a stop bit. RB is valid only when RxRDY = 1. Only a single FIFO position is occupied when a break is received. Further entries to FIFO are inhibited until RxD returns to high state for at least one-half bit-time, which equals two successive PSC clock edges.<br>**MIR / FIR**—End of frame<br>0 The next byte to be read from the RX-FIFO is not the last one of the frame.<br>1 The next byte to be read from the RX-FIFO is the last one of the frame. This bit is effective when RxRDY=1.<br>**Other Modes**—Reserved |
| 1 | FE/<br>PHYERR | **UART / SIR**—Framing Error— is not used (always 0) in Codec mode.<br>0 No framing error occurred.<br>1 No stop bit detected when corresponding FIFO data character received. Stop bit-check occurs in middle of first stop bit position. FE is valid only when RxRDY=1.<br>MIR / FIR—Physical layer error<br>0 No error<br>1 In MIR mode, this denotes that the RX received an abort. In FIR mode, this denotes that there was a decode error. This bit can be cleared by the reset error status command in the CR.<br>**Other Modes**—Reserved |
| 2 | PE | **UART / SIR**—Parity Error—valid only if RxRDY = 1. PE is not used (always 0) in Codec mode.<br>0 No parity error occurred.<br>1 If MR1[PM]=0x (with parity or force parity), corresponding FIFO character was received with incorrect parity. If MR1[PM]=11 (multidrop), PE stores received A/D bit.\<br>**Other Modes**—Reserved |
| 3 | ORERR | Overrun Error<br>Indicates whether an overrun occurs. For purposes of overrun, FIFO full means all FIFO space is occupied; the Rx FIFO threshold is irrelevant to overrun.<br>0 No overrun occurred.<br>1 One or more characters in Rx data stream were lost. ORERR sets on receipt of a new character when FIFO is full and a character is already in the shift register waiting for an empty FIFO position. When this occurs, the character in the Rx shift register and its break detect, framing error status, and parity error, if any, are lost. ORERR is cleared by the RESET ERROR STATUS command in CR.<br>Also see the note on the end of this table. |

**Table 15-8. Status Register Field Descriptions (Sheet 2 of 3)**

| Bit | Name | Description |
|---|---|---|
| 4 | TxEMP/<br>URERR | **UART / SIR**—Transmitter Empty<br>0 Tx buffer not completely empty. Either a character is being shifted out, or Tx is disabled. Tx is enabled/disabled by programming CR[TC].<br>1 Tx has underrun (both the Tx holding register and Tx shift registers are empty). This bit sets after transmission of the last stop bit of a character, if there are no characters in the Tx holding register awaiting transmission.<br>**Other Modes**—Underrun error<br>0 No error.<br>1 Underrun error occurred, which means the number of Tx FIFO bytes is 0, the Tx shift register is empty, and a FrameSync occurs. In other words, the time has come to transmit a new sample, but no sample is available in the Tx shift register. Unlike UART mode, TxEMP high indicates an error condition similar to the overrun condition (ORERR = 1), and as such it is now cleared the same way as ORERR, by a RESET ERROR STATUS command in the CR and not by a reset Tx command in the CR.<br>Also see the note on the end of this table. |
| 5 | TxRDY | Transmitter Ready<br>0 Tx FIFO contains a number of data bytes greater than the TFALARM register value, or the Tx is disabled.<br>1 Tx FIFO is “almost empty” as defined by the TFALARM. TxRDY sets when the number of Tx FIFO bytes falls to, or below, the TFALARM value, due to data transfer from the Tx FIFO to the Tx shift register. Once set, TxRDY remains set until the number of empty bytes in the Tx FIFO falls to 4 times the granularity level specified in the TFCNTL register. In UART mode this bit only asserts if the Tx is enabled.<br>Also see the note on the end of this table. |
| 6 | FFULL | Rx FIFO full<br>0 The Rx FIFO is not “almost full”<br>1 Rx FIFO is “almost full” as defined by the RALARM. FFULL sets as soon as the number of bytes in the Rx FIFO exceeds the RALARM value, due to the transfer of data from the Rx shift register to the Rx FIFO. Once set, FFULL remains set until the number of bytes in the Rx FIFO falls to the granularity level specified in the RFCNTL register.<br>Also see the note on the end of this table. |
| 7 | RxRDY | Receiver Ready<br>0 There is no data in the Rx FIFO.<br>1 One or more characters were received and are waiting in the Rx buffer FIFO.<br>Also see the note on the end of this table. |
| 8 | CDE<br>DEOF | **UART**—$\overline{\text{DCD}}$ Error<br>0 The $\overline{\text{DCD}}$ input is negated while receiving data.<br>1 No error<br>**MIR / FIR**—Detect End of Frame<br>0 Rx did not receive an EOF after the last read SR command.<br>1 Rx received the EOF in the frame. In this case, the interrupt and request can be asserted even if the Rx FIFO number is less than the threshold and MR1[1]=1.<br>**Other Modes**—Reserved |
| 9 | Error | Error Status Detect<br>0 The PSC controller detect no errors<br>1 The PSC controller detect an error state. This error is a combination of the error bits: RB, FE, PE, URERR, ORERR from this register and RX and RX FIFO bit from the TFSTAT and RFSTAT register.<br>**Other Modes**—Reserved |
| 10:11 | — | Reserved |

**Table 15-8. Status Register Field Descriptions (Sheet 3 of 3)**

| Bit | Name | Description |
|---|---|---|
| 12 | CMD_SEND | **Normal AC97 Mode**—Command Send ready<br>0 The data in the AC97CMD register was sent out by the AC97 transmitter<br>1 The data in the AC97CMD register was not sent out. A write access to the AC97CMD register set this bit to one. If the AC97 transmitter send out the CMD data then this bit was cleared.<br>**Other Modes**—Reserved |
| 13 | DATA_OVR | **Normal AC97 Mode**— Receive Status Data Overwrite<br>0 No received status data overwrite.<br>1 The received frame contains a new valid data status word in slot2, but the previous received status data word was not read out before the new one was written to the AC97Data register. Therefore the old status data word was lost. A read access to the AC97Data register cleared this bit<br>**Other Modes**—Reserved |
| 14 | DATA_VALID | **Normal AC97 Mode**—Received Status Data<br>0 The received frame doesn't contains valid status data.<br>1 The received frame contains a valid data status word in slot2. The received data are located in the AC97Data register. A read access to the AC97Data register cleared this bit.<br>**Other Modes**—Reserved |
| 15 | UNEX_RX_SLOT | **Normal AC97 Mode**—Unexpected Receive Slots detect<br>0 The received frame contains the slots defined in the AC97Slots register or a frame without AC97 data (frame is empty or contains only slot 1 or slot 2 data). The case that the receive frame contains all expected data slots plus additional data slots will also be accepted. The RX data of the frame which matches this rule will be written to the RX FIFO.<br>1 The AC97 receiver detects a frame which does not match the rules above. The RX data of the frame which triggers this bit will be ignored.<br>**Other Modes**—Reserved |

## NOTE

The FIFO related status bits ORERR, URERR, RxRDY, FFUL and TxRDY will be changed only if the peripheral (transmitter or receiver) access the FIFO. These bits reflect to the related bits in the ISR, therefore only the peripheral side can generate a FIFO access interrupt. The bits in the RFSTAT or TFSTAT register are also set. If the CPU side read from an empty FIFO or write to a full FIFO the status bits in the RFSTAT or TFSTAT register will be set, but the status bit in the SR register are unchanged. An access from the CPU side to the FIFO can't generate an interrupt.

### 15.2.2.4 Clock Select Register (CSR)

The MPC5200B supports only the internal clock as source for the UART / SIR clock generation. For the UART clock generation a prescaler by 16 or 10 is available. For the SIR clock generation only the prescaler by 16 is valid. After reset, the prescaler by 4 for the UART mode and the prescaler by 16 for the SIR mode is selected. Writing “1110” to this register will stop the UART / SIR clock generation.

Address MBAR + 0x04

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | RCS | | | | TCS | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-11. Clock Select Register for UART / SIR Mode**

Address MBAR + 0x04

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-12. Clock Select Register for Other Modes**

**Table 15-9. Clock Select Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | RCS | **UART**—Receiver Clock Select Register<br>0000–1101 choose the prescaler by 16 for the UART receive clock generation<br>1110 disable the clock generation<br>1111 choose the prescaler by 10 for the UART receive clock generation<br>**SIR** —Clock Select Register<br>1110 disable the clock generation<br>others choose the prescaler by 16 for the SIR receive clock generation<br>**Other Modes**—Reserved |
| 4:7 | TCS | **UART**—Transmitter Clock Select Register<br>0000–1101 choose the prescaler by 16 for the UART transmit clock generation<br>1110 disable the clock generation<br>1111 choose the prescaler by 10 for the UART transmit clock generation<br>**SIR** —Clock Select Register<br>1110 disable the clock generation<br>others choose the prescaler by 16 for the SIR transmit clock generation<br>**Other Modes**—Reserved |
| 8:15 | — | Reserved |

### 15.2.2.5 Command Register (CR)

The write-only command registers (CR), provide the commands to the PSC in all modes. Only multiple commands that do not conflict can be specified in a single write to a CR. For example, reset Tx and enable Tx cannot be specified in one command.

Address MBAR + 0x08

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | |
| W | Reserved | MISC | | | TC | | RC | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-13. Command Register for all Modes**

**Table 15-10. Command Register Field Descriptions**

| Bit | Value | Command | Description |
|---|---|---|---|
| 0 | — | | Reserved |
| 1:3 | 000 | no command | — |
| | 001 | reset mode register pointer | Causes MR register address to point to MRS1. |
| | 010 | reset receiver | Immediately disables receiver, clears SR[FFULL,RxRDY], and re-initializes receiver FIFO pointer. No other registers are altered. Because it places the receiver in a known state, use this command instead of RECEIVER DISABLE when reconfigure the receiver. |
| | 011 | reset transmitter | In UART mode, immediately disables Tx and clears SR[TxEMP,TxRDY]. No other registers are altered. Because it places Tx in a known state, use this command instead of TRANSMITTER DISABLE when reconfigure transmitter.<br>In Codec mode, URERR is not cleared by this soft reset. It is cleared the same way as the Rx overflow bit, by a RESET ERROR STATUS command. |
| | 100 | reset error status | In UART mode, clears ISR[RB,FE,PE,ORERR].<br>In Codec mode, command clears ISR[ORERR, URERR, DEOF, CMD_SEND, DATA_OVR, DATA_VALID, UNEX_RX_SLOT]] |
| | 101 | reset break change interrupt | Clears the delta break bit, ISR[DB]. Command has no effect in Codec mode. |
| | 110 | start break | Forces TxD low<br>• If Tx is empty, break may be delayed up to one bit-time.<br>• If Tx is active, break starts when character transmission completes.<br>Break is delayed until any character in Tx shift register is sent. Any character in Tx holding register is sent after the break. Tx must be enabled for command to be accepted. This command ignores the $\overline{\text{CTS}}$ state and has no effect in Codec mode. |
| | 111 | stop break | Causes TxD to go high (mark) within two bit-times. Any characters in the Tx buffer are sent. |

**Table 15-10. Command Register Field Descriptions (continued)**

| Bit | Value | Command | Description |
|---|---|---|---|
| 4:5 | 00 | no action taken | Causes Tx to stay in current mode.<br>• If Tx is enabled, it remains enabled.<br>• If Tx is disabled, it remains disabled. |
| | 01 | transmitter enable | Enables operation of Tx channels. SR[TxEMP,TxRDY] sets. If Tx is already enabled, this command has no effect.<br>In UART mode, TxRDY and TxEMP bits in SR become asserted.<br>In Codec mode:<br>Tx FIFO can be loaded while Tx is disabled, unlike in UART mode. Therefore this command does not affect TxRDY or URERR behavior. It does not automatically set TxRDY and URERR. If no data is written to Tx FIFO, URERR sets at the first FrameSync after Tx is enabled.<br>In AC97 mode:<br>URERR sets if Tx FIFO is empty, Tx is enabled, Rx detects a “Codec Ready” condition, and a FrameSync occurs before samples are written to the Tx FIFO.<br>**Note:** In Codec / AC97 mode it’s not possible to use the transmitter without the receiver. To transmit data only, also the receiver must be enabled! |
| | 10 | transmitter disable | Terminates Tx operation and clears SR[TxEMP,TxRDY].<br>• If a character is being sent when Tx is disabled, transmission completes before Tx becomes inactive.<br>• If Tx is already disabled, the command has no effect.<br>In UART mode, SR[TxEMP,TxRDY] are negated.<br>In Codec mode SR[TxEMP] is negated.<br>Tx does not clear SR[TxRDY] unless PSC is in remote loop-back or auto-echo mode. In Codec mode, unlike UART mode, the Tx FIFO may be loaded while Tx is disabled.<br>**Note:** If the transmitter was disabled and transmit data are available in the TX FIFO, then TX line is not driven low, the frame signal is also visible on the TX line. |
| | 11 | — | Reserved, do not use. |
| 6:7 | 00 | no action taken | Causes receiver to stay in current mode.<br>• If receiver is enabled, it remains enabled.<br>• If receiver is disabled, it remains disabled. |
| | 01 | receiver enable | Enables receiver<br>• If PSC module is not in multidrop mode (MR1[PM] $\neq$ 11), RECEIVER ENABLE command enables channel's receiver and forces it into a search-for-start-bit state. In multidrop mode the Rx continuously monitors the received data regardless of whether it is enabled or not.<br>• If receiver is already enabled, this command has no effect. |
| | 10 | receiver disable | Immediately disables receiver. In UART mode any character being received is lost. The command does not affect receiver status bits or other control registers.<br>• If the PSC module is programmed for local loop-back or multidrop mode, the receiver operates even though this command is selected.<br>• If the receiver is already disabled, the command has no effect.<br>In Codec mode, if the receiver is disabled while a character is being received, reception completes before the receiver becomes inactive. |
| | 11 | — | Reserved, do not use. |

**Note:** This field selects a single command.

### 15.2.2.6 Rx Buffer Register (RB)

Data are read from the Rx FIFO by reading from this read-only register. The Rx FIFO size is 512 bytes. To read data from the RX FIFO you can also use the RFDATA register, see Section 15.2.2.30, “Rx FIFO Data (RFDATA).”

Address MBAR + 0x0C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | RB[0:15] | | | | | | | | | | | | | | | |
| W | Used by Tx Buffer | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | RB[16:31] | | | | | | | | | | | | | | | |
| W | Used by Tx Buffer | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-14. Rx Buffer Register for UART/SIR/MIR/FIR/Codec8/16/32**

Address MBAR + 0x0C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | RB[0:15] | | | | | | | | | | | | | | | |
| W | Used by Tx Buffer | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | RB[16:19] | | | | SOF | Reserved | | | | | | | | | | |
| W | Used by Tx Buffer | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-15. Rx Buffer Register or AC97**

Address MBAR + 0x0C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | RB[0:15] | | | | | | | | | | | | | | | |
| W | Used by Tx Buffer | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | RB[16:23] | | | | | | | | Reserved | | | | | | | |
| W | Used by Tx Buffer | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-16. Rx Buffer Register for Codec24**

**Table 15-11. Rx Buffer Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:19 (AC97) or 0:31 (other) | RB | **AC97** (0:19)—Received data—AC97 data must be read one complete sample at a time, where all samples except time slot #0 are 20 bits. Time slot #0 data is in bits 0:15. Bit 20 is 1 in the first sample of a new frame.<br>Bit 20 contains the “Start of Frame Indicator” SOF:<br>0 RB[0:19] is not the first sample in the frame.<br>1 RB[0:15] is the first sample in a new frame. The number 0 slot is called the TAG slot.<br>The bits [21:31] are reserved at this mode.<br>**UART/SIR/MIR/FIR/Codec8** (0:31)—Received data—For these modes, data can be read 1, 2 or 4 bytes at a time. For one byte at a time, all bytes must be read from bits 0:7. For 2 bytes at a time, data must be read from bits 0:15. Lower-bit data was received before upper-bit data.<br>**Codec16** (0:31)—Received data—For these modes, data can be read 2 or 4 bytes at a time. For 2 bytes at a time, data must be read from bits 0:15. Lower-bit data was received before upper-bit data.<br>**Codec24** (0:23)—Received data—For these modes, data must be read 4 bytes at a time. The lower 24 bits contain the received data word.<br>**Codec32** (0:31)—Received data—For these modes, data must be read 4 bytes at a time. |

### 15.2.2.7 Tx Buffer Register (TB)

Data is written to the Tx FIFO by writing to this write-only register. The Tx FIFO size is 512 bytes. To write data to the TX FIFO you can also use the TFDATA register, see Section 15.2.2.38, “Tx FIFO Data (TFDATA).”

**NOTE**

Please note that the TX FIFO access via TB address will be blocked if the PSC was set to UART or SIR mode **and** the transmitter is disabled. The access via TFDATA will be never blocked.

Address MBAR + 0x0C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Used by Rx Buffer | | | | | | | | | | | | | | | |
| W | TB[0:15] | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Used by Rx Buffer | | | | | | | | | | | | | | | |
| W | TB[16:31] | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-17. Tx Buffer Register for UART/SIR/MIR/FIR/Codec8/16/32 Modes**

Address MBAR + 0x0C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Used by Rx Buffer | | | | | | | | | | | | | | | |
| W | TB[0:15] | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Used by Rx Buffer | | | | | | | | | | | | | | | |
| W | TB[16:19] | | | | SOF | Reserved | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-18. TX Buffer Register for AC97) Modes**

Address MBAR + 0x0C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Used by Rx Buffer | | | | | | | | | | | | | | | |
| W | TB[0:15] | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Used by Rx Buffer | | | | | | | | | | | | | | | |
| W | TB[16:23 | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-19. Tx Buffer Register for Codec24**

**Table 15-12. Tx Buffer Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:19 (AC97) or 0:31 (other) | RB | **"legacy" AC97** (0:19)—Transmit data—AC97 data must be written one complete sample at a time, where all samples except time slot #0 are 20 bits, time slot #0 data is in bits 0:15. Bit 20 is 1 in the first sample of a new frame.<br>Bit 20 contains the "Start of Frame Indicator" SOF:<br>0 RB[0:19] is not the first sample in the frame.<br>1 RB[0:15] is the first sample in a new frame. The number 0 slot is called the TAG slot.<br>The bits [21:31] are reserved at this mode.<br>**"normal" AC97** (0:19)—Transmit data—AC97 data for the expected time slots (3 to 12). The lower 20 bits contain the valid data word.<br>**UART/SIR/MIR/FIR/Codec8** (0:31)—Transmit data—For these modes, data can be written 1, 2 or 4 bytes at a time. For one byte at a time, all bytes must be written to bits 0:7. For 2 bytes at a time, data must be written to bits 0:15. Lower-bit data is stored before upper-bit data.<br>**Codec16** (0:31)—Transmit data—For these modes, data can be written 2 or 4 bytes at a time. For 2 bytes at a time, data must be written to bits 0:15. Lower-bit data is stored before upper-bit data.<br>**Codec24** (0:23)—Transmit data—For these modes, data must be written 4 bytes at a time. The lower 24 bits contain the valid data word.<br>**Codec32** (0:31)—Transmit data—For these modes, data must be written 4 bytes at a time. |

### 15.2.2.8 Input Port Change Register (IPCR)

The read-only IPCR register shows the current state and change-of-state for the Modem control input port.

Address MBAR + 0x10

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | Reserved | | D_DCD | D_CTS | Reserved | | DCD | CTS |
| W | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-20. Input Port Change Register for UART/SIR/MIR/FIR Modes**

Address MBAR + 0x10

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | SYNC | Reserved | D_DCD | D_CTS | Reserved | | DCD | CTS |
| W | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-21. Input Port Change Register for Codec Mode**

**Table 15-13. Input Port Change Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | SYNC | **Codec**—Sync detected.<br>0 Has not detected sync.<br>1 Detected sync (Frame = 1 in Codec Modes or Sync = 1 in AC97 mode)<br>**Other Modes**—Reserved |
| 1 | — | Reserved |
| 2 | D_DCD | Delta DCD.<br>0 No change-of-state has occurred since the last time the CPU read the IPCR. A read of the IPCR also clears the IPCR D_DCD bit.<br>1 A change of state, lasting more than a certain time (1/16 or 1bit duration determined by the CSR, CTUR and CTLR) has occurred at $\overline{\text{DCD}}$ input. When this bit is set, the ACR can be programmed to generate an interrupt to the processor. |
| 3 | D_CTS | Delta CTS.<br>0 No change-of-state has occurred since the last time the CPU read the IPCR. A read of the IPCR also clears the IPCR D_CTS bit.<br>1 A change of state, lasting a certain time has occurred at $\overline{\text{CTS}}$ input. When this bit is set, the ACR can be programmed to generate an interrupt to the processor.<br>After the enable of the PSC the CPU must read this bit to make sure, that this bit is cleared at the beginning of the transmission. |
| 4:5 | — | Reserved |
| 6 | DCD | Current state of $\overline{\text{DCD}}$ port. This input is double latched.<br>0 The current state of the DCD input port is low.<br>1 The current state of the DCD input port is high. |
| 7 | CTS | Current state of $\overline{\text{CTS}}$ port. This input is double latched.<br>0 The current state of the $\overline{\text{CTS}}$ input port is low.<br>1 The current state of the $\overline{\text{CTS}}$ input port is high. |

### 15.2.2.9 Auxiliary Control Register (ACR)

The write-only ACR register controls Tx/Rx handshaking.

Address MBAR + 0x10

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | |
| W | Reserved | | | | | | IEC1 | IEC0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-22. PSC1 Auxiliary Control Register for all Modes**

**Table 15-14. Auxiliary Control Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:5 | — | Reserved |
| 6 | IEC1 | Interrupt enable control for D_DCD.<br>0 D_DCD has no effect on the IPC in the ISR.<br>1 When the D_DCD becomes high, IPC bit in the ISR sets (causing an interrupt if mask is set). |
| 7 | IEC0 | Interrupt enable control for D_CTS.<br>0 D_CTS has no effect on the IPC in the ISR.<br>1 When the D_CTS becomes high, IPC bit in the ISR sets (causing an interrupt if mask is set).<br>After enable the PSC the D_CTS bit can be set, therefore it's important to clear the D_CTS bit before enable this interrupt. |

### 15.2.2.10 Interrupt Status Register (ISR)

The read-only ISR register provides status for all potential interrupt sources. Register contents is masked by the IMR.

- If an ISR flag sets and the corresponding IMR bit is also set, the internal interrupt output is asserted.
- If the corresponding IMR bit is cleared, the ISR bit state has no effect on the interrupt output.

Address MBAR + 0x14

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | IPC | Reserved | | ORERR | TxEMP | DB | RxRDY FFULL | TxRDY | Reserved | Error | Reserved | | | | | |
| W | Reserved | | | | | | | | | | | | | | | |
| RESET: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-23. Interrupt Status Register for UART / SIR Mode**

Address MBAR + 0x14

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | IPC | Reserved | | ORERR | URERR | Reserved | RxRDY FFULL | TxRDY | DEOF | Error | Reserved | | CMD_SEND | DATA_OVR | DATA_VALID | UNEX_RX_SLOT |
| W | Reserved | | | | | | | | | | | | | | | |
| RESET: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-24. Interrupt Status Register other Modes**

**Table 15-15. Interrupt Status Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | IPC | Input port change interrupt.<br>0 No IPC event was occurred.<br>1 An IPC event was occurred. |
| 1:2 | — | Reserved |
| 3 | ORERR | Overrun Error<br>This bit is identical to the ORERR bit in the SR register. To clear this interrupt use the reset error status command in the CR register. |
| 4 | TxEMP/ URERR | **UART / SIR**—TxEMP<br>This bit is identical to the TxEmpty bit in the SR register.<br>**Other Modes**—Underrun Error<br>This bit is identical to the URERR bit in the SR register. To clear this interrupt use the reset error status command in the CR register. |
| 5 | DB | **UART / SIR**—Delta Break<br>Receiver detect an Delta Break state.<br>**Other Modes**—Reserved |

**Table 15-15. Interrupt Status Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 6 | RxRDY FFULL | Rx FIFO over threshold. If MR1[1]=1, then this bit is identical to the FFULL bit in the SR register. If MR1[1]=0, then this bit is identical to the RxRDY bit in the SR register. |
| 7 | TxRDY | Transmitter ready - identical to the TxRDY bit in the SR register |
| 8 | DEOF | **MIR / FIR**—Detect End of Frame<br>0 Rx did not receive an EOF after the last read SR command.<br>1 Rx received the EOF in the frame. In this case, the interrupt and request can be asserted even if the Rx FIFO number is less than the threshold and MR1[1]=1.<br>To clear this interrupt use the reset error status command in the CR register.<br>**Other Modes**—Reserved |
| 9 | Error | Error<br>This bit is identical to the Error bit in the SR register. To clear this interrupt use the reset error status command in the CR register. |
| 10:11 | — | Reserved |
| 12 | CMD_SEND | **Normal AC97 Mode**—Command Send ready<br>This bit is identical to the CMD_SEND bit in the SR register. To clear this interrupt use the reset error status command in the CR register.<br>**Other Modes**—Reserved |
| 13 | DATA_OVR | **Normal AC97 Mode**—Receive Data Overwrite<br>This bit is identical to the DATA_OVR bit in the SR register. To clear this interrupt use the reset error status command in the CR register.<br>**Other Modes**—Reserved |
| 14 | DATA_VALID | **Normal AC97 Mode**—Received Status Data<br>This bit is identical to the DATA_VALID bit in the SR register. To clear this interrupt use the reset error status command in the CR register.<br>**Other Modes**—Reserved |
| 15 | UNEX_RX_ SLOT | **Normal AC97 Mode**—Unexpected RX Slots detect<br>This bit is identical to the UNEX_RX_SLOT bit in the SR register. To clear this interrupt use the reset error status command in the CR register.<br>**Other Modes**—Reserved |

### 15.2.2.11 Interrupt Mask Register (IMR)

The write-only IMR register selects corresponding bits in the ISR that cause an interrupt.

- If one ISR bit is set and the corresponding IMR bit is also set, the internal interrupt output is asserted.
- If the corresponding bit in IMR is 0, the state of the ISR bit has no effect on the interrupt output. The IMR does not mask reading the ISR.

Address MBAR + 0x14

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | IPC | Reserved | | ORERR | TxEMP | DB | RxRDY FFULL | TxRDY | Reserved | Error | Reserved | | | | | |
| RESET: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-25. Interrupt Mask Register for UART / SIR Mode**

Address MBAR + 0x14

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | IPC | Reserved | | ORERR | URERR | Reserved | RxRDY FFULL | TxRDY | DEOF | Error | Reserved | | CMD_SEND | DATA_OVR | DATA_VALID | UNEX_RX_SLOT |
| RESET: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-26. Interrupt Mask Register for other Modes**

**Table 15-16. Interrupt Mask Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | IPC | Input port change interrupt.<br>0 IPC has no effect on the interrupt.<br>1 Enable the interrupt for IPC in the ISR register. |
| 1:2 | — | Reserved |
| 3 | ORERR | Overrun Error<br>0 ORERR has no effect on the interrupt.<br>1 Enable the interrupt for ORERR |
| 4 | TxEMP/ URERR | UART / SIR—TxEMP<br>0 TxEMP has no effect on the interrupt.<br>1 Enable the interrupt for TxEMP<br>**Other Modes**—Underrun Error.<br>0 URERR has no effect on the interrupt.<br>1 Enable the interrupt for URERR. |

**Table 15-16. Interrupt Mask Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 5 | DB | **UART / SIR** —Delta Break<br>0 DB has no effect on the interrupt.<br>1 Enable the interrupt for DB<br>**Other Modes**—Reserved |
| 6 | RxRDY FFULL | Rx FIFO over threshold<br>0 RxRDY/FFULL has no effect on the interrupt.<br>1 Enable the interrupt for RxRDY/FFULL. |
| 7 | TxRDY | Transmitter ready<br>0 TxRDY has no effect on the interrupt.<br>1 Enable the interrupt for TxRDY |
| 8 | DEOF | **MIR / FIR** Detect End of Frame<br>0 DEOF has no effect on the interrupt.<br>1 Enable the interrupt for DEOF.<br>**Other Modes**—Reserved |
| 9 | Error | Error<br>0 Error bit in the ISR register has no effect on the interrupt.<br>1 Enable the interrupt for Error |
| 10:11 | — | Reserved |
| 12 | CMD_SEND | **Normal AC97 Mode**—Command Send ready<br>0 CMD_SEND bit in the ISR register has no effect on the interrupt.<br>1 Enable the interrupt for CMD_SEND<br>**Other Modes**—Reserved |
| 13 | DATA_OVR | **Normal AC97 Mode**—Receive Data Overwrite<br>0 DATA_OVR bit in the ISR register has no effect on the interrupt.<br>1 Enable the interrupt for DATA_OVR<br>**Other Modes**—Reserved |
| 14 | DATA_VALID | **Normal AC97 Mode**—Received Status Data<br>0 DATA_VALID bit in the ISR register has no effect on the interrupt.<br>1 Enable the interrupt for DATA_VALID<br>**Other Modes**—Reserved |
| 15 | UNEX_RX_ SLOT | **Normal AC97 Mode**—Unexpected RX Slots detect<br>0 UNEX_RX_SLOT bit in the ISR register has no effect on the interrupt.<br>1 Enable the interrupt for UNEX_RX_SLOT<br>**Other Modes**—Reserved |

### 15.2.2.12 Counter Timer Upper Register (CTUR)

This write-only register holds the upper bytes of the preload value used by the timer to provide a given Baud rate. Reading from this register shows the current value of the Baud rate generation counter.For a detailed description see the next section, Section 15.2.2.13, “Counter Timer Lower Register (CTLR).”

Address MBAR + 0x18

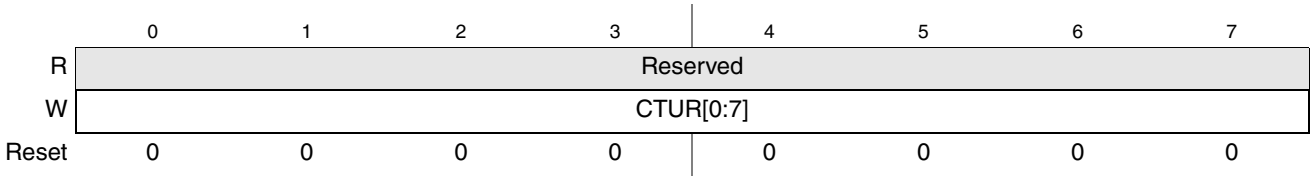



**Figure 15-27. Counter Timer Upper Register for all Modes**

**Table 15-17. Counter Timer Upper Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | CTUR | **Code**—Frame Sync width, define the number of Bit clocks during the FrameSync signal is active.<br>FrameSync Width = CTUR[0:7]+1<br>**UART/ SIR/ SPI** —Baud rate prescaler value.<br>See next section, Section 15.2.2.13, “Counter Timer Lower Register (CTLR) “<br>**Other**—Reserved |

### 15.2.2.13 Counter Timer Lower Register (CTLR)

This write-only register hold the lower bytes of the preload value used by the timer to provide a given Baud rate. Reading from this register shows the current value of the Baud rate generation counter.

Address MBAR + 0x1C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | |
| W | CTLR[0:7] | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-28. Counter Timer Lower Register for all Modes**

**Table 15-18. Counter Timer Lower Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | CTLR | **UART**—Baud rate prescale value. The Baud rate is calculated as:<br>$\text{Baud rate} = \frac{\text{IPB clock frequency}}{\text{CT[0:15] x prescaler}}$ where: CT[0:15] = {CTUR[0:7], CTLR[0:7]}<br>The minimum CT value is 1; 0 denotes counter stop.<br>The prescaler was defined in the CSR register.<br>**SIR**—Baud rate prescale value. The Baud rate is calculated as:<br>$\text{Baud rate} = \frac{\text{IPB clock frequency}}{\text{CT[0:15] x 32}}$ where: CT[0:15] = {CTUR[0:7], CTLR[0:7]}<br>The minimum CT value is 1; 0 denotes counter stop.<br>**SPI**—Delay After Transfer (DTL)<br>$\text{DTL} = \frac{\text{CT[0:15]} + 2}{\text{IPB clock frequency}} + \frac{3}{\text{Mclk frequency}}$<br>where:<br>CT[0:15] = {CTUR[0:7], CTLR[0:7]}<br>**Other**—Reserved<br>**Note:** Length of Delay after Transfer (DTL) — When the PSC is in SPI mode (SICR[SPI] = 1), the Counter Timer is used to determine the length of time that the PSC delays after each serial transfer, i.e., the length of time that SS stays high/inactive between consecutive transfers. This is a feature that exists in a QSPI. Delay after transfer can be used to ensure that the deselect time requirement (for peripherals having such a requirement) is met. Some peripherals must be deselected for a minimum period of time between consecutive serial transfers. A delay after transfer can be inserted between consecutive transfers to a given peripheral to ensure that its minimum deselect time requirement is met or to allow serial A/D converters to complete conversion before the next transfer is made. |

### 15.2.2.14 Codec Clock Register (CCR)

This register defines the divider for the FrameSync and BitClk generation for Codec mode. This register value has only effect, if the GenClk bit in the PSC Control Register SICR was set to one. In UART, SIR, and AC97 mode this register is reserved

Address MBAR + 0x20

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | FrameSyncDiv[0:7] | | | | | | | | BitClkDiv[8:15] | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | BitClkDiv[0:7] | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-29. Codec Clock Register for Codec Mode**

Address MBAR + 0x20

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | BitClkDiv[8:15] | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | BitClkDiv[0:7] | | | | | | | | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-30. Codec Clock Register for MIR/FIR Mode**

Address MBAR + 0x20

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-31. Codec Clock Register for other Modes**

**Table 15-19. Codec Clock Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | FrameSyncDiv | **Codec**—Frame Sync Divider<br>FrameSync is generated internally by dividing down the Bit Clock. The FrameSyncDiv defines the number of Bit clock cycles between two active frame edges:<br>FrameSync Length = FrameSyncDiv[0:7] + 1<br>For more information see also Section 15.3.2.3, "Transmitting and Receiving in "Soft Modem" Codec Mode"<br>**Codec / SPI**—delay before SCK (DSCKL)<br>When the PSC is in SPI mode (SICR[SPI] = 1), the FrameSyncDiv divider is used to determine the length of time the PSC delays after SS goes low/active before the first SCK transition of the serial transfer. This is a feature that exists in a QSPI. The following equation determines the actual delay before SCK:<br>$\text{DSCKL delay} = \frac{\text{FrameSyncDiv[0:7]} + 1}{\text{Mclk Frequency}}$<br>**other Modes**—Reserved<br>**Note:** The value 0x00 stops this counter and disables the clock generator. |
| 7:23 | BitClkDiv | **Codec**—Bit Clock Divider<br>Bit clock is generated internally by dividing down the Mclk frequency as follows:<br>$\text{BitClk frequency} = \frac{\text{Mclk Frequency}}{\text{BitClkDiv[0:15]} + 1}$<br>**Codec SPI**—Baud Rate<br>SCK is generated internally by dividing down the Mclk frequency as follows:<br>$\text{SCK frequency} = \frac{\text{Mclk Frequency}}{\text{BitClkDiv[0:15]} + 1}$<br>The minimum supported BitClkDiv for SPI mode is 3.<br>**MIR / FIR**—Irda clock<br>IrdaClk is generated internally by dividing down the Mclk frequency as follows:<br>$\text{IrdaClk frequency} = \frac{\text{Mclk Frequency}}{\text{BitClkDiv[0:15]} + 1}$<br>**other Modes**—Reserved<br>**Note:** The value 0x00 stops this counter and disables the clock generator. |

The Mclk frequency is generated in the Clock Distribution Module (CDM) by dividing down the $f_{system}$ frequency as follows:

$$\text{Mclk} = \frac{f_{system}}{\text{MclkDiv [8:0]} + 1}$$

There is a separate cdm_pscX_bitclk_config register in the CDM for each of PSC1,2,3 and 6, which are the PSCs available for use in Codec modes. These cdm_pscX_bitclk_config registers are further described in the CDM Section 5.5.1.11, "PSC1 Mclock Configuration Register" to Section 5.5.1.14, "PSC6 (IrDA) Mclock Configuration Register."

### 15.2.2.15 AC97 Slots Register (AC97Slots)

This write only register defines which slots are expected in a receive AC97 frame and which slots will be send in an AC97 TX frame. If the received frame doesn't match the expected slots the SR[UNEXP_RX_SLOTS] bit will be set. This register has effect only if the and AC97 mode is selected in the SICR register and if the EnAC97 bit is active.

Address MBAR + 0x24

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | Reserved | | | | | | | | TX_Slots[3:12] | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | Reserved | | | | | | | | RX_Slots[3:12] | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-32. AC97 Slots Register**

**Table 15-20. AC97 Slots Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:5 | — | Reserved |
| 6:15 | TX_Slots[3:12] | **Normal AC97 Mode**—Expected Receive Slots<br>The bits in this register specifies which data slots [3:12] will be send in an AC97 TX frame. Each bit represents one data slot. The AC97 transmitter will use this information to generate the Slot0 and will read out the according number of data words from the TXFIFO. If the TXFIFO is empty an empty AC97 frame will be send until new data are available.<br>**Other Modes**—Reserved |
| 16:21 | — | Reserved |
| 22:31 | RX_Slots[3:12] | **Normal AC97 Mode**—Expected Receive Slots<br>The bits in this register specifies which data slots [3:12] in the receive AC97 frame must contain valid data. The AC97 Codec select the valid data slots by setting the according data valid bit in Slot0[12:3]. Each bit represents one data slot. If the received valid slots not match the expected slots the "Unexpected Slot Received" state occurred. See register SR. Only if the received slots matched the expected slots the received data will be written to the RXFIFO. If the Receiver detect an AC97 frame without data (Frame is empty or contains only status data) the "Unexpected Slot Received" state will not occurred.<br>**Other Modes**—Reserved |

### 15.2.2.16 AC97 Command Register (AC97CMD)

This register contains the AC97 address for transmit slot1 and the AC97 command data for transmit slot 2. A write access to any byte of this register will set the SR[CMD_SEND] bit to one. The AC97 transmitter generate a frame with valid slot1 and slot2 and paste the values of this register to the next transmitted slot1 and slot2. If the data was send, then the SR[CMD_SEND] bit will be cleared by the transmitter.

Address MBAR + 0x28

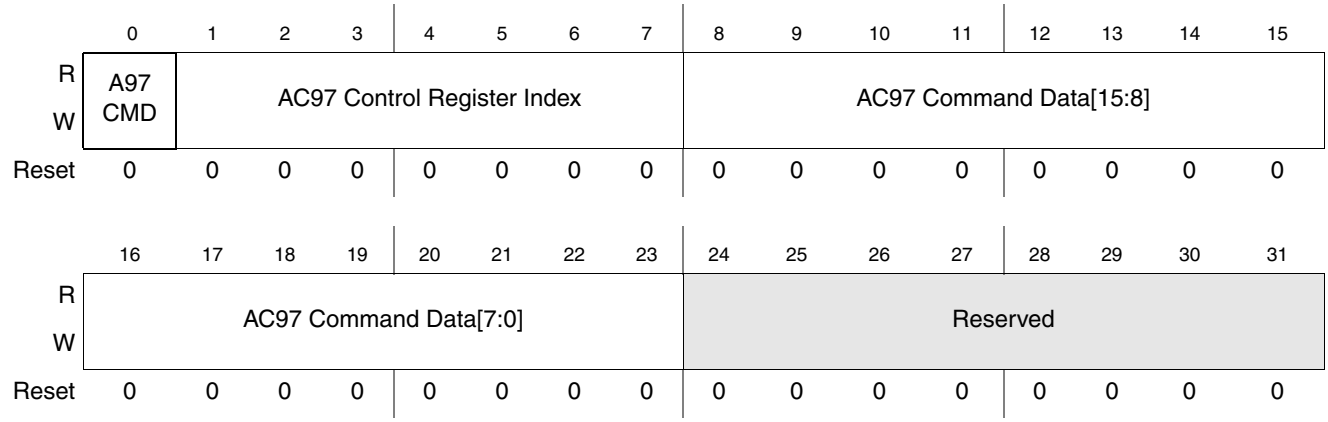



**Figure 15-33. AC97 Command Register**

**Table 15-21. AC97 Command Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | AC97 CMD | **Normal AC97 Mode**—AC97 Command<br>This bit indicates if the access to the Control Register is a read or write access. It will be paste to the Slot1 bit 19.<br>0 write access<br>1 read access<br>**Other Modes**—Reserved |
| 1:7 | AC97 Control Register Index | **Normal AC97 Mode**—AC97 address Register<br>This register contains target control register address. It will be paste to the Slot1 bit 18 to 12.<br>**Other Modes**—Reserved |
| 6:23 | AC97 Command Data | **Normal AC97 Mode**—AC97 Command Data Register<br>This register is used define the command data value for a write command. It will be paste to the Slot2 bit 19 to 4.<br>**Other Modes**—Reserved |
| 24:31 | — | Reserved |

### 15.2.2.17 AC97 Status Data Register (AC97Data)

This read-only register contains the received response of an AC97 read command. If this register contains new data then the SR[DATA_VALID] will be set to one by the receiver. A read access to this register cleared the SR[DATA_VALID] bit.

Address MBAR + 0x2C

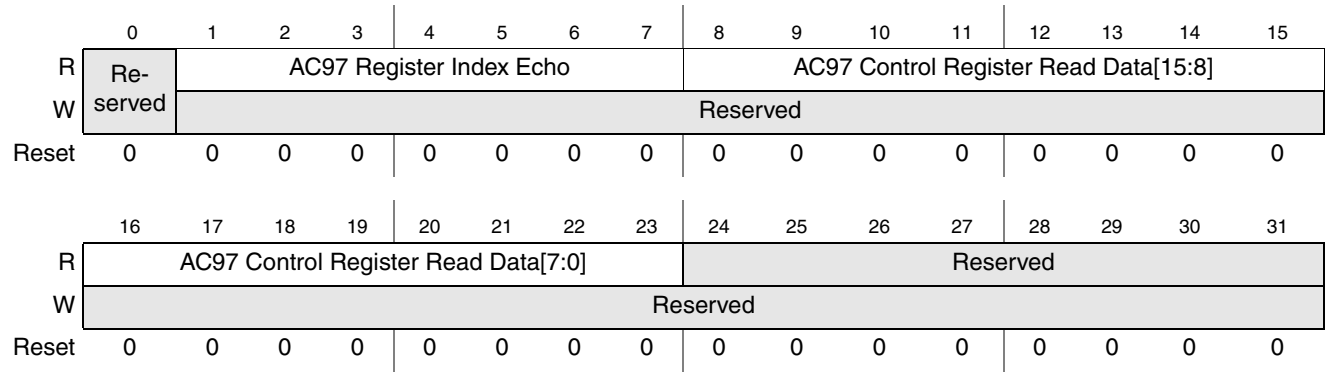

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
R
W
Reset
Re-served
AC97 Register Index Echo
AC97 Control Register Read Data[15:8]
Reserved
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
AC97 Control Register Read Data[7:0]
Reserved
Reserved
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

**Figure 15-34. AC97 Status Data Register**

**Table 15-22. AC97 Status Data Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | — | Reserved |
| 1:7 | AC97 Register Index Echo | **Normal AC97 Mode**—AC97 Register Index Echo<br>This register contains the received Register Index Echo from the RX Slot0.<br>**Other Modes**—Reserved |
| 6:23 | AC97 Control Register ReadData | **Normal AC97 Mode**—AC97 Control Register Read Data<br>This register contains the received control data from Rx Slot2.<br>**Other Modes**—Reserved |
| 24:31 | — | Reserved |

### 15.2.2.18 Interrupt Vector Register (IVR)

This register is not used since the MPC5200 does not use interrupt vectors supplied by the peripherals.

Address MBAR + 0x30

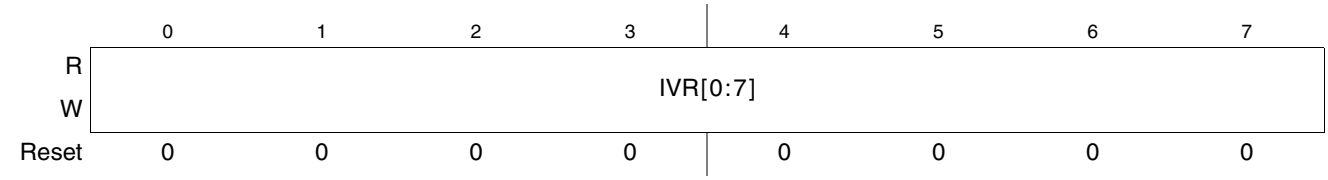



**Figure 15-35. Interrupt Vector Register for all Modes**

**Table 15-23. Interrupt Vector Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | IVR | Interrupt Vector— Not applicable for MPC5200. |

### 15.2.2.19 Input Port Register (IP)

This read-only IP register shows the current state of the input ports.

Address MBAR + 0x34

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | DCD | CTS |
| W | Reserved | | | | | | | |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |

**Figure 15-36. Input Port Register for UART/SIR/MIR/FIR Modes**

Address MBAR + 0x34

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | Reserved | TGL | Reserved | | | | DCD | CTS |
| W | Reserved | | | | | | | |
| Reset | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |

**Figure 15-37. Input Port Register for Codec Mode**

Address MBAR + 0x34

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | LPWR | TGL | Reserved | | | | DCD | CTS |
| W | Reserved | | | | | | | |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |

**Figure 15-38. Input Port Register for AC97 Mode**

**Table 15-24. Input Port Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | LPWR | **AC97**—Low power mode in AC97 mode<br>0 Codec is in low power mode.<br>1 Usual operation.<br>**Other Modes**—Reserved |
| 1 | TGL | **AC97 / Codec**—Test usage. Toggle by FrameSync.<br>**Other Modes**—Reserved |
| 2:5 | — | Reserved |
| 6 | DCD | Current state of the $\overline{\text{DCD}}$ input.<br>0 $\overline{\text{DCD}}$ input is low.<br>1 $\overline{\text{DCD}}$ input is high. |
| 7 | CTS | Current state of the $\overline{\text{CTS}}$ input<br>0 Input port $\overline{\text{CTS}}$ is low.<br>1 Input port $\overline{\text{CTS}}$ is high. |

### 15.2.2.20 Output Port 1 Bit Set (OP1)

This is a write-only register. Output ports are asserted by writing to this register.

Address MBAR + 0x38

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | |
| W | Reserved | | | | | | RES | RTS |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-39. Output Port 1 Bit Set Register for all Mode**

**Table 15-25. Output Port 1 Bit Set Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:5 | — | Reserved |
| 6 | RES | Assert RES output.<br>0 No operation<br>1 Asserts output port RES, (RES becomes 0) |
| 7 | RTS | **AC97**—Reserved<br>**Other Modes**—Assert RTS output.<br>0 No operation<br>1 Asserts output port $\overline{\text{RTS}}$, ($\overline{\text{RTS}}$ becomes 0) |

### 15.2.2.21 Output Port 0 Bit Set (OP0)

This is a write-only register. Output ports are negated by writing to this register.

Address MBAR + 0x3C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | |
| W | Reserved | | | | | | RES | RTS |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-40. Output Port 0 Bit Set Register for all Modes**

**Table 15-26. Output Port 0 Bit Set Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:5 | — | Reserved |
| 6 | RES | Assert RES output.<br>0 No operation<br>1 Negates output port RES, (RES becomes 1). |
| 7 | RTS | **AC97**—Reserved<br>**Other Modes**—Assert $\overline{\text{RTS}}$ output.<br>0 No operation<br>1 Negates output port $\overline{\text{RTS}}$, ($\overline{\text{RTS}}$ becomes 1). |

### 15.2.2.22 Serial Interface Control Register (SICR)

This register sets the main operation mode.

Address MBAR + 0x40

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | ACRB | AWR | DTS1 | SHDIR | SIM[3:0] | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | GenClk | I2S | ClkPol | SyncPol | CellSlave | Cell2xClk | ESAI | EnAC97 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | SPI | MSTR | CPOL | CPHA | UseEOF | Disable_<br>EOF | Reserved | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-41. Serial Interface Control Register for all Modes**

**Table 15-27. Serial Interface Control Register Field Descriptions (Sheet 1 of 3)**

| Bit | Name | Description |
|---|---|---|
| 0 | ACRB | **AC97**—AC97 Cold Reset to the transceiver in PSC. This bit was prepared for backward compatibility with the MCF5407 USART. It is recommended to use OP1 and OP0 registers to set and to reset AC97 reset line.<br>0 The transceiver recovers from low power mode in AC97.<br>1 The transceiver stays in the current state.<br>**Other Modes**—Reserved |
| 1 | AWR | **AC97**—AC97 Warm Reset (to the PSC and off-chip AC97 Codec)<br>0 AC97 warm reset is negated. $\overline{\text{RTS}}$ output functions normally as the AC97 FrameSync.<br>1 Force “1” on $\overline{\text{RTS}}$ output, which is used as the AC97 FrameSync, and the PSC recovers from AC97 power down mode.<br>**Other Modes**—Reserved |
| 2 | DTS1 | **Codec**—Delay of time slot #1.<br>0 First bit of first time slot of a new frame starts at the rising edge of FrameSync.<br>1 First bit of first time slot of a new frame starts one bit clock cycle after the rising edge of FrameSync.<br>**Other Modes**—Reserved |
| 3 | SHDIR | **Codec**—Shift Direction.<br>0 msb first<br>1 lsb first<br>**Other Modes**—Reserved |

**Table 15-27. Serial Interface Control Register Field Descriptions (Sheet 2 of 3)**

| Bit | Name | Description |
|---|---|---|
| 4:7 | SIM[3:0] | PSC operation mode.<br>**CAUTION**: When the operating mode change occurs, all Rx/Tx and error statuses are reset. Rx and Tx are disabled.<br>0000 UART mode, $\overline{DCD}$ input ignored<br>1000 UART mode, $\overline{DCD}$ input is effective<br>x001 Codec mode, 8-bit data<br>x010 Codec mode, 16-bit data<br>x011 AC97 mode<br>0100 SIR model, $\overline{DCD}$ input ignored<br>1100 SIR mode, $\overline{DCD}$ input is effective<br>x101 MIR mode<br>x110 FIR mode<br>0111 Codec mode, 24-bit data<br>1111 Codec mode, 32-bit data |
| 8 | GenClk | **Codec**—Generate Bit Clock and FrameSync, not used to enable the SPI master mode but this bit must be set additional to the MSTR bit to enable the SPI master mode<br>0 Use bit clock and FrameSync provided by external device<br>1 Use bit clock and FrameSync generated internally from Mclk<br>**MIR / FIR**—Generate Bit Clock and FrameSync<br>0 Use for clock generation the external Clk from Pad IR_USB_CLK<br>1 Use for clock generation the internal Mclk<br>**Other Modes**—Reserved |
| 9 | I2S | **Codec**—$I^2S$ mode<br>0 No $I^2S$ mode supported<br>1 PSC works in $I^2S$ mode<br>**Other Modes**—Reserved |
| 10 | ClkPol | **Codec**—Bit Clock Polarity, this bit must be cleared during SPI mode<br>0 Data in is sampled on the falling edge of the BitClk and data out is shifted on the rising edge<br>1 Data in is sampled on the rising edge of the BitClk and data out is shifted on the falling edge<br>**Other Modes**—Reserved |
| 11 | SyncPol | **Codec**—FrameSync Polarity, this bit must be cleared during SPI mode<br>0 FrameSync is low true<br>1 FrameSync is high true<br>**Codec $I^2S$**—FrameSync Polarity<br>0 Frame starts if LRCK is low<br>1 Frame starts if LRCK is high<br>**Other Modes**—Reserved |
| 12 | CellSlave | **Codec**—Cell Phone Slave<br>0 PSC is not a slave to PSC1<br>1 PSC uses Bit Clock from PSC1 master as its Mclk |
| 13 | Cell2xClk | **Codec** —Cell Slave 2x Clock Frequency - takes effect only when bit 12 CellSlave = 1<br>0 PSC Mclk frequency = Bit Clock from PSC1 master<br>1 PSC Mclk frequency = 2x the Bit Clock from PSC1 master<br>**Other Modes**—Reserved |
| 14 | ESAI | **Codec**—Enhanced Serial Audio Interface<br>0 PSC doesn't support the ESAI mode.<br>1 PSC support the ESAI mode. This mode allows the PSC to send and receive more the one data word per frame, if the frame length is greater than the word length. The PSC send only complete data words.<br>**Other Modes**—Reserved |

**Table 15-27. Serial Interface Control Register Field Descriptions (Sheet 3 of 3)**

| Bit | Name | Description |
|---|---|---|
| 15 | EnAC97 | **Codec** —Enhanced AC97 mode - takes effect only when the AC97 mode is selected (SIM = 0x3)<br>0 If the AC97 mode was selected then PSC use the “legacy AC97” mode to transmit and receive the data.<br>1 If the AC97 mode was selected then PSC use the “normal AC97” mode to transmit and receive the data.<br>**Other Modes**—Reserved |
| 16 | SPI | **Codec**—SPI mode<br>0 PSC does not behave like an SPI<br>1 PSC behaves like an SPI<br>**Other Modes**—Reserved |
| 17 | MSTR | **Codec**—SPI Master mode - takes effect only when bit SICR[SPI mode] = 1, also the bit GenClk must be set to enable the clock generation during SPI mode<br>0 PSC behaves as an SPI slave<br>1 PSC behaves as an SPI master<br>**Other Modes**—Reserved |
| 18 | CPOL | **Codec**—SPI Clock Polarity - takes effect only when bit SICR[SPI mode] = 1<br>This bit selects an inverted or non-inverted SPI clock. To transmit data between SPI modules, the SPI modules must have identical CPOL values<br>0 Active-high clocks selected; SCK idles low<br>1 Active-low clocks selected; SCK idles high<br>**Other Modes**—Reserved |
| 19 | CPHA | **Codec**—SPI Clock Phase<br>This bit is used to shift the SCK serial clock.To transmit data between SPI modules, the SPI modules must have identical CPHA values<br>0 Data transfer starts which assertion of $\overline{SS}$<br>1 Data transfer starts with the first edge of SCK<br>**Other Modes**—Reserved |
| 20 | UseEOF | **Codec**—Use End-of-Frame flag takes effect only when bit 16 SPI mode = 1<br>0 Either 1, 2 or 4 bytes are transferred while Slave Select (SS) is held low, as determined by Codec8, Codec16, Codec24 or Codec32 being selected by SICR[SIM]<br>1 Multiple bytes are transferred while maintaining SS low, up to and including the next byte read from the Tx FIFO that has its EOF flag set<br>**Other Modes**—Reserved |
| 21 | Disable_ EOF | **UART/SIR** —Disable EOF generation<br>0 The UART receiver generate an EOF tag if an UART error was detected. For more information’s regarding the UART errors (RB, FE,PE, CDE,) see register SR.<br>1 The UART receiver doesn’t generate an EOF tag if an UART error was detected<br>**Other Modes**—Reserved |
| 22:23 | — | Reserved |

### 15.2.2.23 Infrared Control 1 (IRCR1)

This register controls the configuration in one of the IrDA modes (SIR/MIR/FIR).

Address MBAR + 0x44

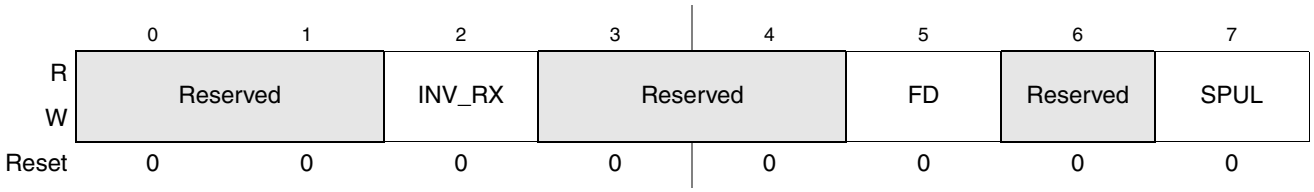



**Figure 15-42. Infrared Control 1 for SIR Mode**

Address MBAR + 0x44

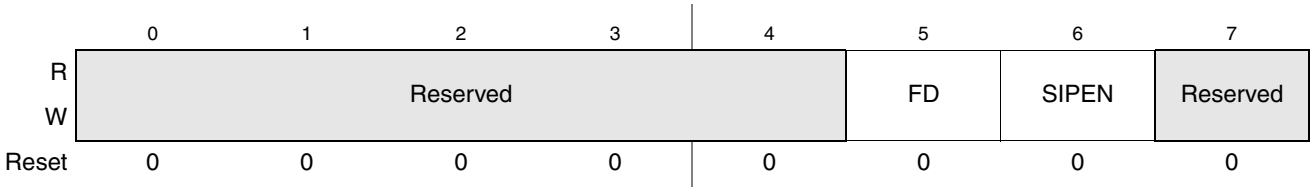



**Figure 15-43. Infrared Control 1 for MIR/FIR Modes**

**Table 15-28. Infrared Control 1 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2 | INV_RX | **SIR / MIR / FIR**—Invert the RX line<br>0 The receiver doesn't invert the receive line.<br>1 The receiver invert the receive line.<br>**Other Modes**—Reserved |
| 3:4 | — | Reserved |
| 5 | FD | **SIR / MIR / FIR**—Full duplex enable<br>0 The receiver in IrDA mode is disabled while the TX is busy.<br>1 The receiver in IrDA mode is not disabled while the TX is busy. This bit should not be set in usual operations. In loop back channel mode, CM=10, this bit is automatically set.<br>**Other Modes**—Reserved |
| 6 | SIPEN | **MIR / FIR**—Send SIP enable after every frame<br>0 SIP is sent only when the SIPREQ bit in the IRCR2 becomes high.<br>1 The TX always send 1.6 μs SIP after the STO flag in order to inform slow speed devices that higher speed device is connecting.<br>For more informations about the SIP pulse see also Figure 15-87.<br>**Other Modes**—Reserved |
| 7 | SPUL | **SIR**—SIR pulse width<br>0 SIR pulse width is 3/16 of the bit duration.<br>1 SIR pulse width is 1.6 μs<br>**Other Modes**—Reserved |

### 15.2.2.24 Infrared Control 2 (IRCR2)

This register controls the configuration in one of the IrDA modes (SIR/MIR/FIR).

Address MBAR + 0x48

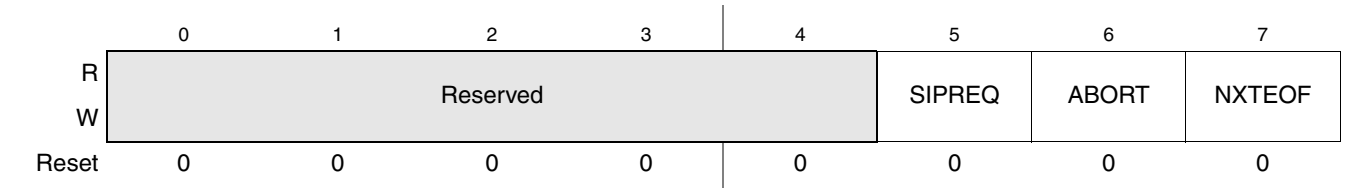



**Figure 15-44. Infrared Control 2 for MIR/FIR Modes**

Address MBAR + 0x48

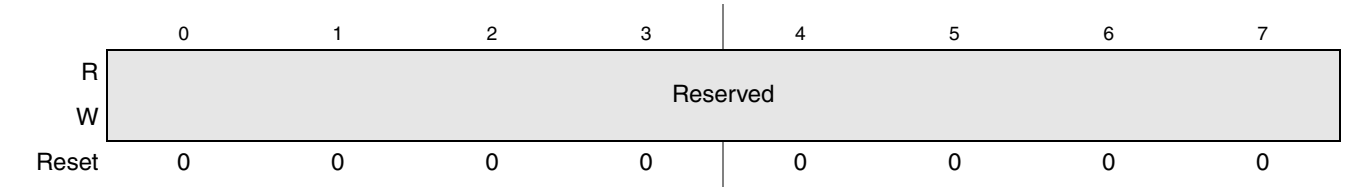



**Figure 15-45. Infrared Control 2 for other Modes**

**Table 15-29. Infrared Control 2 Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:4 | — | Reserved |
| 5 | SIPREQ | **MIR / FIR**—Request to send SIP<br>0 No operation<br>1 If the TX becomes idle state, the TX starts to send one SIP pulse. This bit keeps high until the TX finishes sending a SIP and becomes low automatically when the TX finishes sending a SIP.<br>For more informations about the SIP pulse see also Figure 15-87.<br>**other Modes**—Reserved |
| 6 | ABORT | **MIR / FIR**— Abort output<br>0 Stop sending abort sequence.<br>1 While the TX is sending data or CRC, writing 1 to this bit causes the TX immediately start to output abort sequence (2 or more illegal symbol “0000” in FIR mode, or 7 or more consecutive 1 in MIR mode). Before the next frame is transmitted, this bit must be reset.<br>**other Modes**—Reserved |
| 7 | NXTEOF | **SIR / MIR / FIR**— Next is the last byte. This bit works independent form the mode. For other modes which support the framing, like SPI, you can also use this bit to mark the last bit of frame.<br>0 The next write data is not the last byte in a frame.<br>1 The next write data is the last byte in the current frame. When the processor performs a write to the TB, an EOF mark is added to the data in the TX-FIFO memory. This bit is cleared after writing to the transmit buffer. This bit is usually set by IP bus write operation. During the CommBus transfer, the signal transmit done line indicate the end of frame, therefore this bit is not used by the CommBus write operation.<br>**other Modes**—Reserved |

### 15.2.2.25 Infrared SIR Divide Register (IRSDR)

This register set the SIR pulse width. To set the SIR mode Baud rate see Section 15.2.2.12, "Counter Timer Upper Register (CTUR)." This register is reserved in other modes.

Address MBAR + 0x4C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | IRSTIM[0:7] | | | | | | | |
| Reset | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |

**Figure 15-46. Infrared SIR Divide Register for SIR Mode**

Address MBAR + 0x4C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-47. Infrared SIR Divide Register for other Modes**

**Table 15-30. Infrared SIR Divide Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | IRSTIM | **SIR**—Timer counter value for 1.6us pulse<br>In SIR mode, this is used to make 1.6 μs pulse when SPUL in the IRCR1 is high. This value should be set so that<br>IPB clock period * IRSTIM = 1.6 μs<br>Reset value is 54(0x36) and this is for 33 MHz bus clock.<br>**Other Modes**—Reserved |

### 15.2.2.26 Infrared MIR Divide Register (IRMDR)

This register set the MIR mode Baud rate. This register is reserved in other modes.

Address MBAR + 0x50

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | FREQ | M_FDIV | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-48. Infrared MIR Divide Register for MIR Mode**

Address MBAR + 0x50

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-49. Infrared MIR Divide Register for other Modes**

**Table 15-31. Infrared MIR Divide Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | FREQ | **MIR**—0.576 M bps mode.<br>0 The Baud rate is 1.152 M bps.<br>1 If the Baud rate is 0.576 Mbps, this bit should be set high in order to output 1.<br>For more informations about the SIP pulse see also Figure 15-87<br>**Other Modes**—Reserved |
| 1:7 | M_FDIV | **MIR**—Clock divide ratio in MIR mode. The bit frequency is derived by:<br>$f_{bit} = \frac{f_{IrdaClk}}{M\_FDIV + 1}$<br>This bit frequency should be 0.576 or 1.152 MHz. In order to send a quarter bit duration pulse and receive minimum pulse described in the IrDA spec, (M_FDIV + 1) should be a factor of 4 and larger than or equal to 8. Table 15-32 shows the selectable divide factor and the input clock frequency on IrdaClk port. For more informations about the frequency generation see also Figure 15-86,Section 15.2.2.14, “Codec Clock Register (CCR)” and Section 15.3.4.2, “PSC in MIR Mode.”<br>**Other Modes**—Reserved |

**Table 15-32. Frequency Selection in MIR Mode**

| M_FDIV[1:7] | Frequency of IrdaClk [MHz] | |
|---|---|---|
| | 1.152 Mbps | 0.576 Mbps |
| 0x07 | 9.216 | 4.6080 |
| 0x0B | 13.824 | 6.912 |
| 0x0F | 18.432 | 9.216 |
| 0x13 | 23.040 | 11.520 |
| 0x17 | 27.648 | 13.824 |
| ... | ... | ... |
| 0x7F | 147.456 | 73.728 |

### 15.2.2.27 Infrared FIR Divide Register (IRFDR)

This register set the FIR mode Baud rate. This register is reserved in other modes.

Address MBAR + 0x54

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | F_FDIV | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-50. Infrared FIR Divide Register for MIR Mode**

Address MBAR + 0x54

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-51. Infrared FIR Divide Register for other Modes**

**Table 15-33. Infrared FIR Divide Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:7 | F_FDIV | **FIR**—Clock divide ratio in FIR mode.<br>The bit frequency is derived by:<br>$f_{bit} = \frac{f_{IrdaClk}}{F\_FDIV + 1}$<br>This bit frequency should be 8 MHz. In order to receive the minimum pulse width described in the IrDA spec, (F_FDIV + 1) should be larger than or equal to 4. Table 15-34 shows several frequency selection. For more informations about the frequency generation see also Figure 15-86, Section 15.2.2.14, “Codec Clock Register (CCR)” and Section 15.3.4.3, “PSC in FIR Mode.”<br>**Other Modes**—Reserved |

**Table 15-34. Frequency Selection for FIR Mode**

| F_FDIV[3:0] | Frequency of IrdaClk [MHz] |
|---|---|
| 0x3 | 32.0 |
| 0x4 | 40.0 |
| 0x5 | 48.0 |
| 0x6 | 56.0 |
| 0x7 | 64.0 |
| 0x8 | 72.0 |
| 0x9 | 80.0 |
| 0xA | 88.0 |

### 15.2.2.28 Rx FIFO Number of Data (RFNUM)

Address MBAR + 0x58

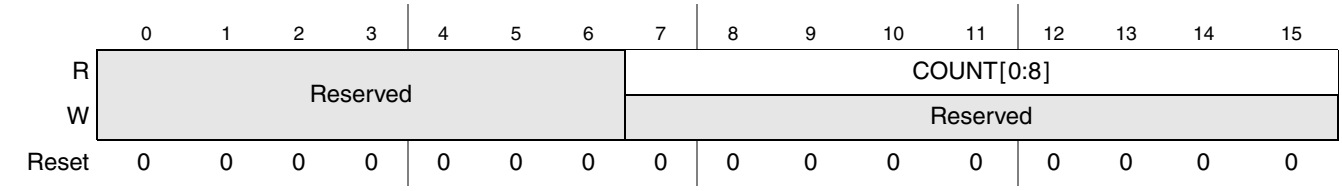



**Figure 15-52. RX FIFO Number of Data Register**

**Table 15-35. Rx FIFO Number of Data Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7:15 | COUNT | Number of data bytes in the Rx FIFO. |

### 15.2.2.29 Tx FIFO Number of Data (TFNUM)

Address MBAR + 0x5C

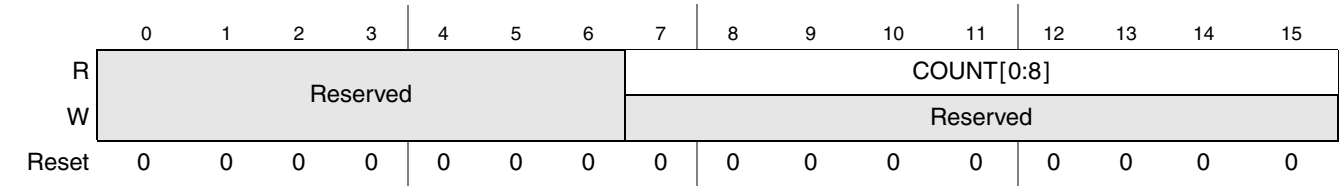



**Figure 15-53. Tx FIFO Number of Data Register**

**Table 15-36. Tx FIFO Number of Data Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:6 | — | Reserved |
| 7:15 | COUNT | Number of data bytes in the Tx FIFO. |

### 15.2.2.30 Rx FIFO Data (RFDATA)

Rx FIFO Data (0x60) is a read - write register to access the internal RX FIFO Data register. Reads from this register reads out the receive data. In addition the register provides the possibility to fill the RX FIFO for debug issues. For more informations about the data format see Section 15.2.2.6, “Rx Buffer Register (RB).”

### 15.2.2.31 Rx FIFO Status (RFSTAT)

For additional informations about the FIFO related status bits see Section 15.2.2.3, “Status Register (SR).”

**NOTE**

To make sure that the PSC never lost the data in the FIFO, the PSC controller avoid writing to a full FIFO or reading from an empty FIFO. Therefore the status bits in the FIFO STAT register never reports an ERROR, UF or OF state. The SR register reports these errors.

Address MBAR + 0x64

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | Frame[3] | Frame[2] | Frame[1] | Frame[0] | Reserved | Error | UF | OF | FR | FULL | ALARM | EMPTY |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-54. Rx FIFO Status Register**

**Table 15-37. RxFIFO Status Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:7 | Frame[3:0] | Frame indicator. Not applicable to PSC FIFO’s, since the PSCs do not recognize frame formats in the serial data stream. |
| 8 | — | Reserved |
| 9 | Error | FIFO error. A FIFO error has occurred due to either underflow, overflow, or read or write pointer out of bounds.This bit is cleared by writing a ‘1’ to it. |
| 10 | UF | Underflow. The read pointer has surpassed the write pointer due to the FIFO having been read when it contained no data. This bit is cleared by writing a ‘1’ to it. |
| 11 | OF | Overflow. The write pointer has surpassed the read pointer due to the FIFO having been written when it was already completely full of data. This bit is cleared by writing a ‘1’ to it. |
| 12 | FR | Frame ready. Not applicable to PSC FIFO’s, since the PSCs do not recognize frame formats in the serial data stream. |
| 13 | FULL | Full. The FIFO is completely full of data. |
| 14 | ALARM | The FIFO is requesting service from either BestComm or CPU. See Section 15.2.2.33, “Rx FIFO Alarm (RFALARM)” for a detailed description. |
| 15 | EMPTY | FIFO Empty. The FIFO is completely empty. |

### 15.2.2.32 Rx FIFO Control (RFCNTL)

Address MBAR + 0x68

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | WFR | COMP | FRAME | GR[2:0] | | |
| Reset | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |

**Figure 15-55. Rx FIFO Control Register**

**Table 15-38. Rx FIFO Control Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2 | WFR | Write frame. Not applicable to PSC FIFOs, since the PSCs do not recognize frame formats in the serial data stream. |
| 3 | COMP | Re-enable requests on frame transmission completion. Not applicable to PSC FIFOs, since the PSCs do not recognize frame formats in the serial data stream. |
| 4 | FRAME | Frame mode enable. THIS BIT MUST BE CLEARED BY WRITING A ‘0’ TO IT, since the PSCs do not recognize frame formats in the serial data stream. |
| 5:7 | GR[2:0] | Last transfer granularity. Amount of data remaining in the Rx FIFO at which the ALARM bit in the status register will go low/inactive. See Section 15.4, “PSC FIFO System” for details. |

### 15.2.2.33 Rx FIFO Alarm (RFALARM)

Address MBAR + 0x6E

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | ALARM | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-56. Rx FIFO Alarm Register**

**Table 15-39. Rx FIFO Alarm Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:15 | ALARM | “Almost full” threshold level. Amount of empty space remaining in the Rx FIFO at which the ALARM bit in the status register goes high/active. See Section 15.4, “PSC FIFO System:” for details. |

### 15.2.2.34 Rx FIFO Read Pointer (RFRPTR)

Address MBAR + 0x72

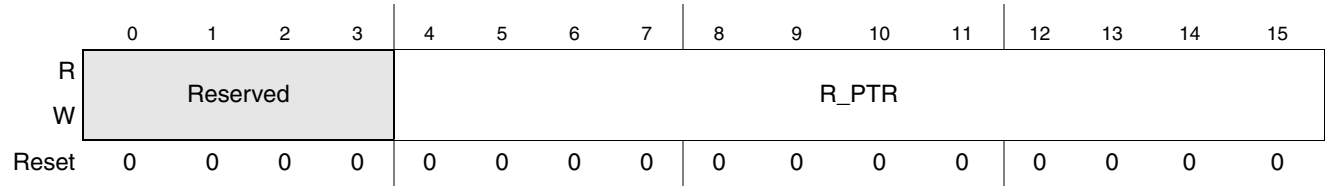



**Figure 15-57. Rx FIFO Read Pointer Register**

**Table 15-40. Rx FIFO Read Pointer Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:15 | R_PTR | Read pointer.This FIFO-maintained pointer points to the next FIFO location to be read. |

### 15.2.2.35 Rx FIFO Write Pointer (RFWPTR)

Address MBAR + 0x76

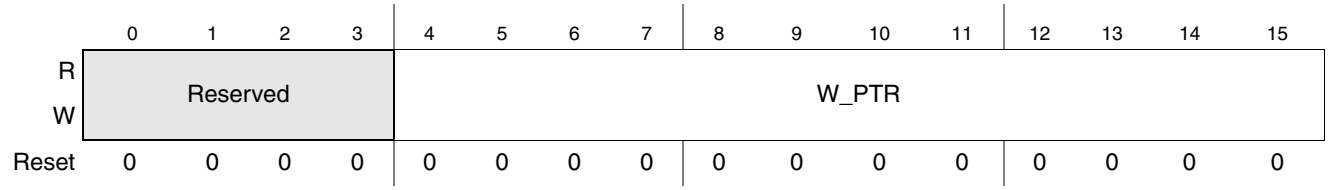



**Figure 15-58. Rx FIFO Read Pointer Register**

**Table 15-41. Rx FIFO Write Pointer Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:15 | W_PTR | Write pointer.This FIFO-maintained pointer points to the next FIFO location to be written to. |

### 15.2.2.36 Rx FIFO Last Read Frame (RFLRFPTR)

Address MBAR + 0x7A

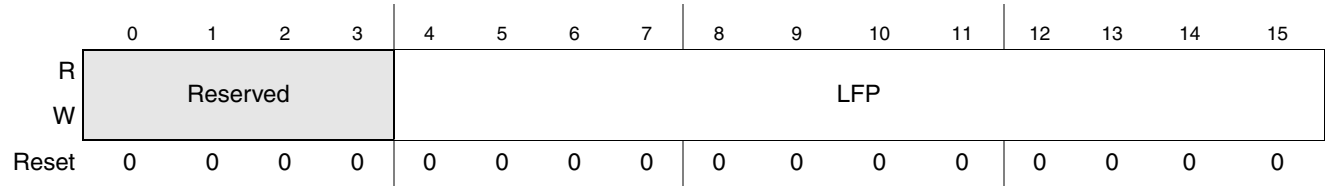



**Figure 15-59. Rx FIFO Last Read Frame Register**

**Table 15-42. Rx FIFO Last Read Frame Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:15 | LFP | Last Frame Pointer. Not applicable to PSC FIFOs, since the PSCs do not recognize frame formats in the serial data stream. |

### 15.2.2.37 Rx FIFO Last Write Frame PTR (RFLWFPTR)

Address MBAR + 0x7C

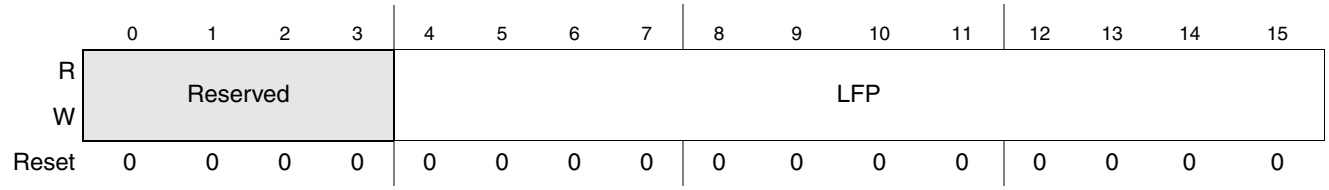



**Figure 15-60. Rx FIFO Last Write Frame PTR Register**

**Table 15-43. Rx FIFO Last Write Frame PTR Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:15 | LFP | Last Frame Pointer. Not applicable to PSC FIFOs, since the PSCs do not recognize frame formats in the serial data stream. |

### 15.2.2.38 Tx FIFO Data (TFDATA)

Tx FIFO Data (0x80) is a read - write register to access the internal TX FIFO Data register. Write to this register write data to the transmit FIFO. Additional the register provide the possibility to read data back from the TX FIFO for debug issues. For more informations about the data format see Section 15.2.2.7, “Tx Buffer Register (TB).”

### 15.2.2.39 Tx FIFO Status (TFSTAT)

For additional informations about the FIFO related status bits see Section 15.2.2.3, “Status Register (SR).”

**NOTE**

To make sure that the PSC never lost the data in the FIFO, the PSC controller avoid writing to a full FIFO or reading from an empty FIFO. Therefore the status bits in the FIFO STAT register never reports an ERROR, UF or OF state. The SR register reports these errors.

Address MBAR + 0x84

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | Frame[3] | Frame[2] | Frame[1] | Frame[0] | Reserved | Error | UF | OF | FR | FULL | ALARM | EMPTY |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 15-61. Tx FIFO Status Register**

**Table 15-44. Tx FIFO Status Register**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:7 | Frame[3:0] | Frame indicator. Not applicable to PSC FIFOs, since the PSCs do not recognize frame formats in the serial data stream. |
| 8 | — | Reserved |
| 9 | Error | FIFO error. A FIFO error has occurred due to either underflow, overflow, or read or write pointer out of bounds.This bit is cleared by writing 1 to it. |
| 10 | UF | Underflow. The read pointer has surpassed the write pointer due to the FIFO having been read when it contained no data. This bit is cleared by writing 1 to it. |
| 11 | OF | Overflow. The write pointer has surpassed the read pointer due to the FIFO having been written when it was already completely full of data. This bit is cleared by writing 1 to it. |
| 12 | FR | Frame ready. Not applicable to PSC FIFOs, since the PSCs do not recognize frame formats in the serial data stream. |
| 13 | FULL | Full. The FIFO is completely full of data. |
| 14 | ALARM | The FIFO is requesting service from either BestComm or CPU. See Section 15.4, “PSC FIFO System” for a detailed description. |
| 15 | EMPTY | FIFO Empty. The FIFO is completely empty. |

### 15.2.2.40 Tx FIFO Control (TFCNTL)

Address MBAR + 0x88

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | WFR | COMP | FRAME | GR[2:0] | | |
| Reset | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |

**Figure 15-62. Rx FIFO Control Register**

**Table 15-45. Rx FIFO Control Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2 | WFR | Write frame. Not applicable for PSC FIFOs, since the PSCs do not recognize frame formats in the serial data stream. |
| 3 | COMP | Re-enable requests on frame transmission completion. Not applicable to PSC FIFO's, since the PSCs do not recognize frame formats in the serial data stream. |
| 4 | FRAME | Frame mode enable. THIS BIT MUST BE CLEARED BY WRITING A '0' TO IT, since the PSCs do not recognize frame formats in the serial data stream. |
| 5:7 | GR[2:0] | Last transfer granularity. Four times this value is the amount of data remaining in the FIFO at which the ALARM bit in the status register will go low/inactive. See Section 15.4, "PSC FIFO System" for details. |

### 15.2.2.41 Tx FIFO Alarm (TFALARM)

Address MBAR + 0x8E

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | ALARM | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Figure 15-63. Tx FIFO Alarm Register**

**Table 15-46. Tx FIFO Alarm Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:15 | ALARM | "Almost empty" threshold level. Amount of data remaining in the Tx FIFO at which the ALARM bit in the status register goes high/active. See Section 15.4, "PSC FIFO System" for details |

## 15.2.2.42 Tx FIFO Read Pointer (TFRPTR)

Address MBAR + 0x92

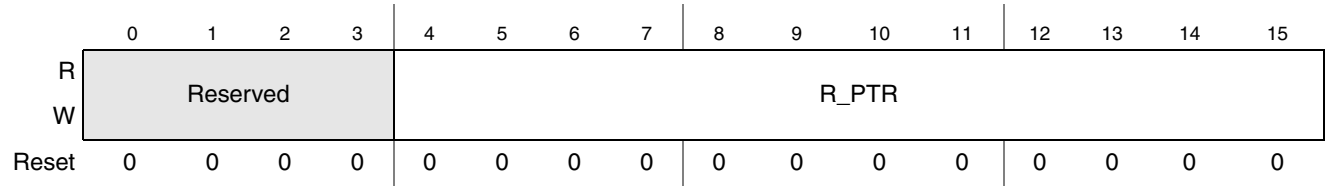



**Figure 15-64. Tx FIFO Read Pointer Register**

**Table 15-47. Tx FIFO Read Pointer Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:15 | R_PTR | Read pointer. This FIFO-maintained pointer points to the next FIFO location to be read |

## 15.2.2.43 Tx FIFO Write Pointer (TFWPTR)

Address MBAR + 0x96

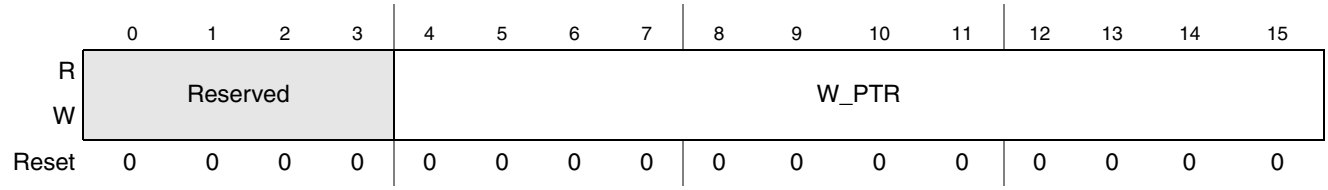



**Figure 15-65. Tx FIFO Write Pointer Register**

**Table 15-48. Tx FIFO Write Pointer Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:15 | W_PTR | Write pointer. This FIFO-maintained pointer points to the next FIFO location to be written to |

### 15.2.2.44 Tx FIFO Last Read Frame (TFLRFPTR)

Address MBAR + 0x9A

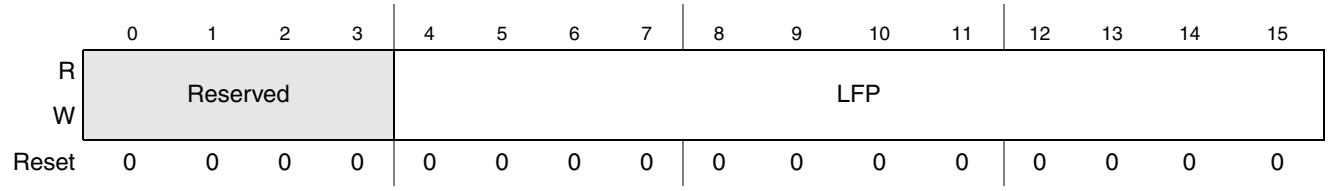



**Figure 15-66. Tx FIFO Last Read Frame PTR Register**

**Table 15-49. Tx FIFO Last Read Frame PTR Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:15 | LFP | Last Frame Pointer. Not applicable to PSC FIFOs, since the PSCs do not recognize frame formats in the serial data stream |

### 15.2.2.45 Tx FIFO Last Write Frame PTR (TFLWFPTR)

Address MBAR + 0x9C

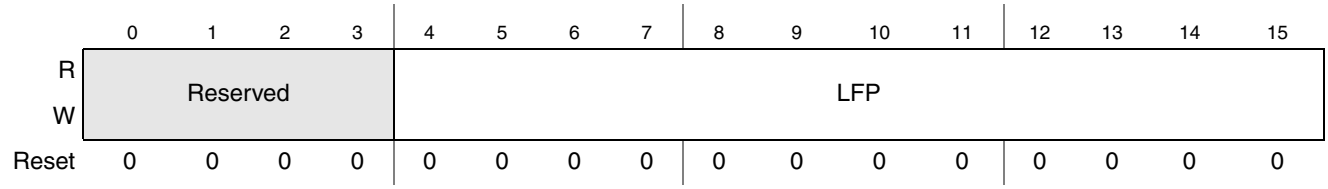



**Figure 15-67. Tx FIFO Last Write Frame PTR Register**

**Table 15-50. Tx FIFO Last Write Frame PTR Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:15 | LFP | Last Frame Pointer. Not applicable to PSC FIFOs, since the PSCs do not recognize frame formats in the serial data stream |

## 15.3 PSC Operation Modes

This section describes the different PSC operation modes including the pin muxing, the module configuration, signal definition and some programming examples. All PSC are independent and can be used at the same time in different modes. But not all PSCs support all modes, Table 15-51 shows an overview.

**Table 15-51. PSC Modes Overview**

| | PSC1 | PSC2 | PSC3 | PSC4 | PSC5 | PSC6 |
|---|---|---|---|---|---|---|
| UART | Yes | Yes | Yes | Yes | Yes | Yes |
| Modem / SPI / $I^2S$ | Yes | Yes | Yes | No | No | Yes |
| Mclk Generation | Yes | Yes | Yes | No | No | no |
| AC97 | Yes | Yes | No | No | No | no |
| IRDA | No | No | No | No | No | Yes |
| “Cell Phone” | Master | Slave | Slave | No | No | Slave |

In this section the following abbreviations will used as:

**Table 15-52. Clock Short Cuts**

| Short Cut | Description |
|---|---|
| $f_{system}$ | Clock from the system PLL |
| Mclk | Clock from the Mclk divider, used as clock input for internal clock generation or as clock output to an external device. Before modify the counter value the Mclk divider must be disable. See Section 5.5.1.11, “PSC1 Mclock Configuration Register” to Section 5.5.1.14, “PSC6 (IrDA) Mclock Configuration Register.” $$Mclk = \frac{f_{system}}{MclkDiv[8:0] + 1}$$ |
| IP bus Clock | Intellectual Property Clock for the internal IP bus system, 33, 66 or 132 MHz, see Section 5.5, “CDM Registers.” |

### 15.3.1 PSC in UART Mode

Select the UART mode by writing the corresponding value to the PSC Control (SICR) register. The PSC UART mode is the default mode after reset. The important registers to configure the PSC for UART mode are:

- SICR register — select the UART mode
- CSR register — select the clock source
- CTIR. CTLR register — select the baud rate
- MR1 register — select the UART mode (parity mode, bits per character)
- MR2 register — select $\overline{\text{RTS}}$ and $\overline{\text{CTS}}$ control, Stop Bit Length
- RFALARM, TFALARM — select the FIFO “Alarm” level
- CR register — enable or disable receiver and transmitter
- Port_config — select the right Pin-Muxing, see Chapter 2, “Signal Descriptions”

#### 15.3.1.1 Block Diagram and Signal Definition for UART Mode

The Figure 15-68 shows the simplified Block Diagram of the PSC for UART mode.

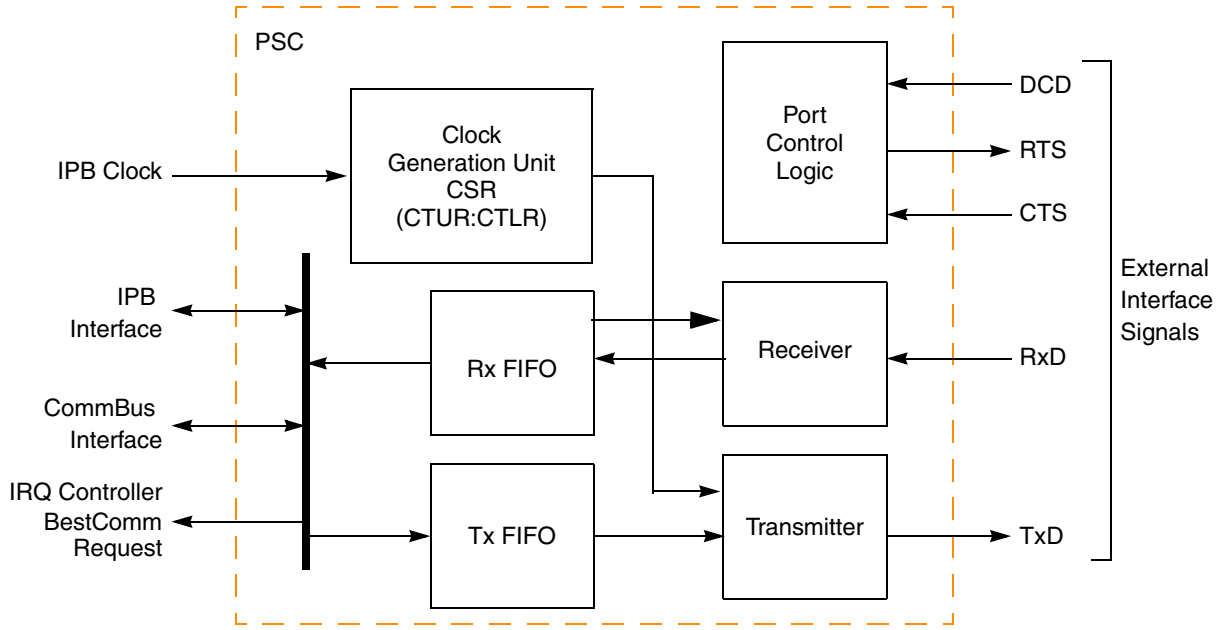



**Figure 15-68. PSC UART Block Diagram**

An internal interrupt request signal ($\overline{\text{IRQ}}$) is provided to notify the Interrupt Controller of an interrupt condition. The output is the logical NOR of unmasked ISR bits. The interrupt level of a PSC module is programmed in the Interrupt Controller in the system integration module: Chapter 7, “System Integration Unit (SIU).” The PSC uses the autovector for the programmed interrupt level.

The PSC can automatically transfer data using the BestComm, rather than interrupting the core. When IMR[FFULL] is 1 and Rx FIFO is full, it can send an interrupt to a BestComm channel so the FIFO data can be transferred to memory.

Table 15-53 briefly describes the PSC module signals.

**NOTE**

The terms “assertion” and “negation” are used to avoid confusion between active-low and active-high signals.

*Asserted* indicates a signal is active, independent of the voltage level.

*Negated* indicates a signal is inactive.

**Table 15-53. PSC Signal Description for UART Mode**

| Signal | Description |
|---|---|
| TxD | Transmitter Serial Data Output—TxD is held high (mark condition) when Tx is disabled, idle, or operating in the local loop-back mode. Data is shifted out on TxD on the falling edge of the clock source, with the least significant bit (lsb) sent first. |
| RxD | Receiver Serial Data Input—Data received on RxD is sampled on the rising edge of the clock source, with the lsb received first. |
| CTS | Clear-to-Send—This input can generate an interrupt on a change of state. |
| RTS | Request-to-Send—This output can be programmed to be negated or asserted automatically by either Rx or Tx. When connected to a transmitter $\overline{CTS}$, $\overline{RTS}$ can control serial data flow. |
| DCD | Data carrier detect Input — In the enhanced UART mode this signal must be assert during the data transmission. |

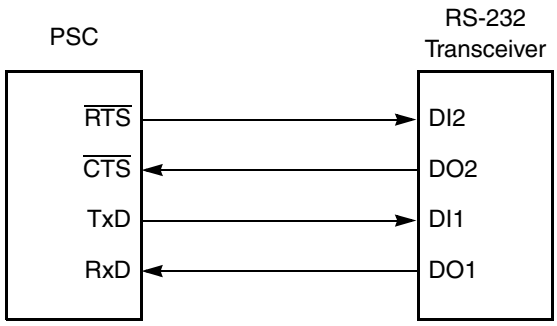



**Figure 15-69. Signal Configuration for a PSC/RS-232 interface**

### 15.3.1.2 UART Clock Generation

IPB clock serves as the basic timing reference for the clock source generator logic, which consists of a Clock Generator and a programmable 16-bit divider dedicated to the PSC and a fix prescaler. The IPB clock passes through the prescaler (divide by 32 or 4) and then through 16-bit divider of the concatenated CTUR and CTLR registers. See also Figure 15-70. Using a 66 MHz IPB clock and the 32 prescaler, the Baud-rate calculation is as follows:

$$\text{Baud rate} = \frac{\text{IPB Clock}}{32 \times \text{divider \{CTUR:CTLR\}}}$$

Let Baud rate = 9600, the divider can be calculated as follows:

$$\text{Divider} = \frac{66\ \text{MHz}}{32 \times 9600} = 215(\text{decimal}) = 0\text{x}00\text{D}7$$

Therefore CTUR = 0x00 and CTLR = 0xD7.

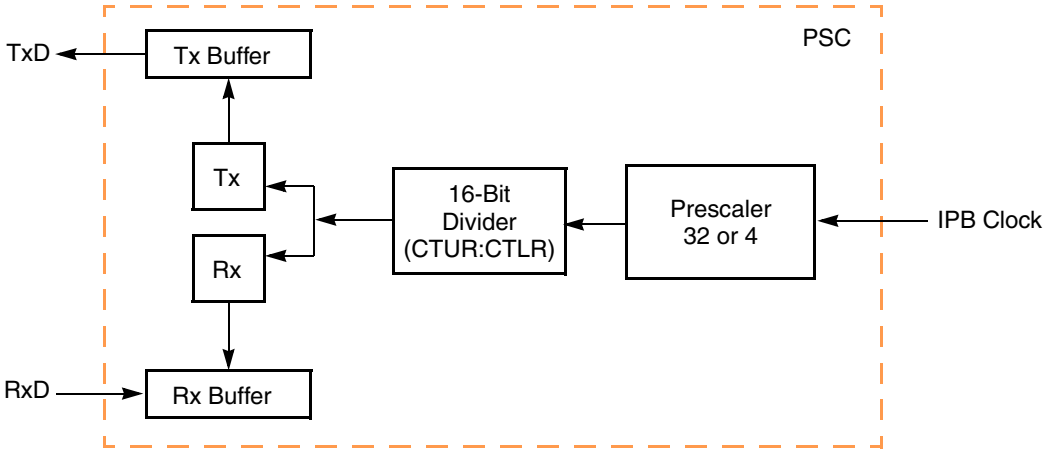



**Figure 15-70. Clocking Source Diagram**

### 15.3.1.3 Transmitting in UART Mode

After a hardware reset all PSC are in UART mode. The transmitter is enabled through the PSC command register (CR). When it is ready to accept a character, the PSC sets SR[TxRDY]. The transmitter converts parallel data from the CPU to a serial bit-stream on TxD. It automatically sends a start bit followed by:

- The programmed number of data bits
- An optional parity bit
- The programmed number of stop bits

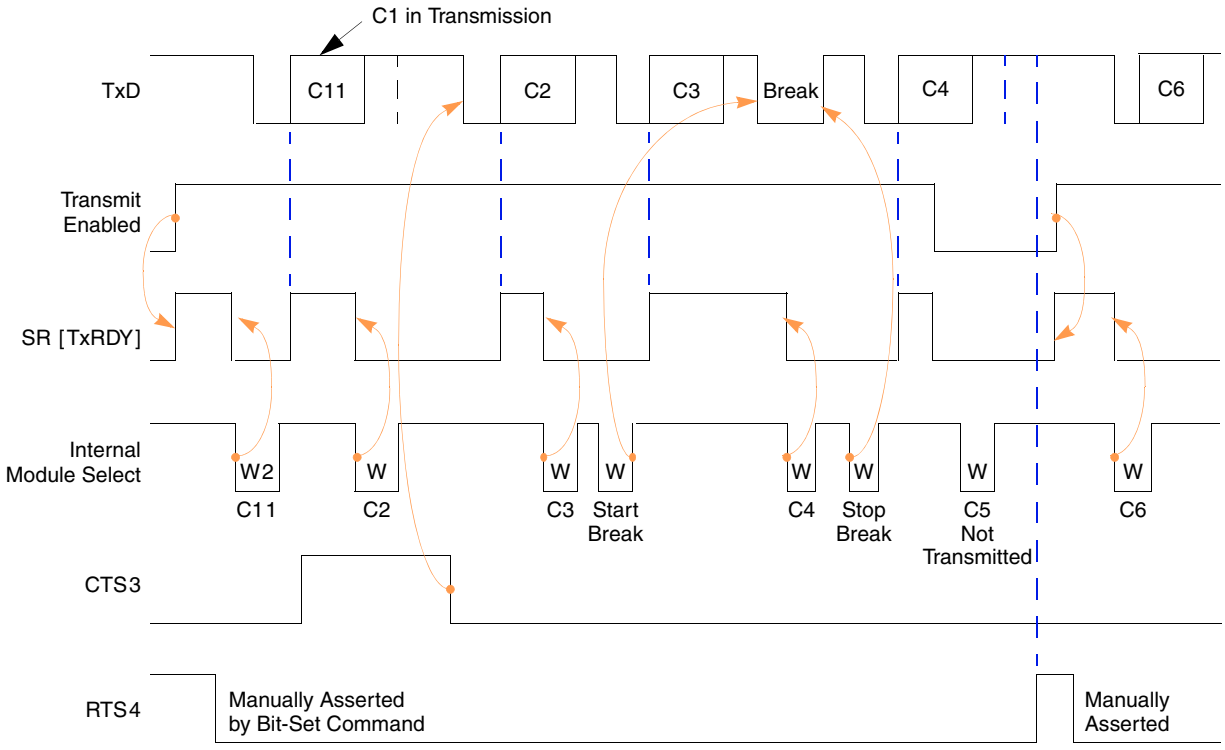
The lsb is sent first. Data is shifted from the Tx output on the falling edge of the clock source.

After the stop bits are sent, if no new character is in the Tx holding register, the TxD output remains high (mark condition) and the Tx empty bit, SR[TxEMP], is set. Transmission resumes and TxEMP is cleared when the CPU loads a new character into the PSC Tx buffer (TB).

- If the transmitter receives a disable command, it continues until any character in the Tx shift register is completely sent.
- If the transmitter is reset through a software command, operation stops immediately.
- If the clear-to-send operation is enabled, $\overline{\text{CTS}}$ must be asserted for the character to be transmitted.
- If $\overline{\text{CTS}}$ is negated in the middle of a transmission, the character in the shift register is sent and TxD remains in mark state until $\overline{\text{CTS}}$ is reasserted.
- If the transmitter is forced to send a continuous low condition by issuing a send break command, the transmitter ignores the state of $\overline{\text{CTS}}$.
- If the transmitter is programmed to automatically negate $\overline{\text{RTS}}$ when a message transmission completes, $\overline{\text{RTS}}$ must be asserted manually before a message is sent.

In applications in which the transmitter is disabled after transmission is complete and $\overline{\text{RTS}}$ is appropriately programmed, $\overline{\text{RTS}}$ is negated one bit-time after the character in the shift register is completely transmitted. The transmitter must be manually re-enabled by reasserting $\overline{\text{RTS}}$ before the next message is to be sent.

Figure 15-71 shows the transmitter functional timing information.




NOTE:
1. Cn = transmit characters
2. W = write
3. MR2[TxCTS] = 1
4. MR2[TxRTS] = 1

**Figure 15-71. Timing Diagram—Transmitter**

### 15.3.1.4 Receiving in UART Mode

After a hardware reset, all PSCs are in UART mode. The receiver is enabled through its CR, as described in Section 15.2.2.5, “Command Register (CR).” Figure 15-72 shows the receiver functional timing.

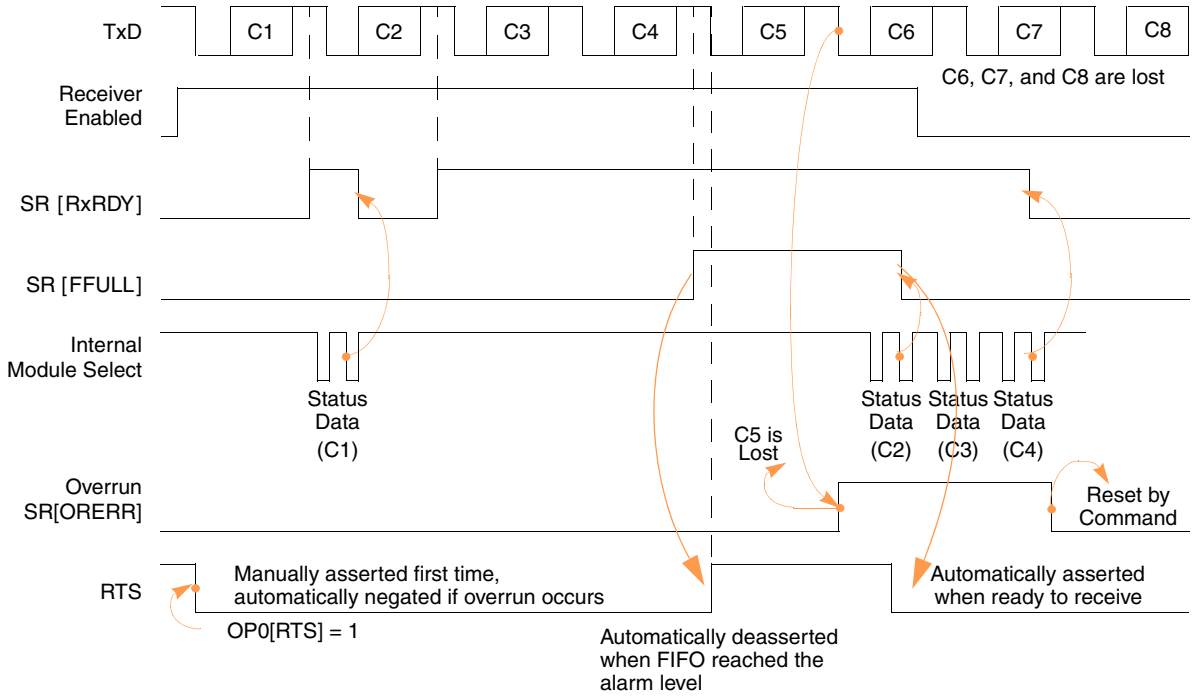



**Figure 15-72. Timing Diagram—Receiver**

When the receiver detects a high-to-low (mark-to-space) transition of the start bit on RxD, the state of RxD is sampled. It samples each 16× clock for eight clocks, starting one-half clock after the transition (asynchronous operation) or at the next rising edge of the bit-time clock (synchronous operation).

- If RxD is sampled high, start bit is invalid; a valid start bit search begins again.
- If RxD is still low, a valid start bit is assumed and receiver continues sampling input at 1-bit time intervals at the theoretical center of the bit. This continues until the proper number of data bits and parity, if any, is assembled and 1 stop bit is detected.

RxD input data is sampled on the rising edge of the programmed clock source. The lsb is received first. Data is then transferred to a receiver holding register and SR[RxRDY] is set. If the character is less than 8bits, the most significant unused bits in the receiver holding register are cleared.

If the MR2[TxRTS] bit was set to one then the user must control the $\overline{\text{RTS}}$ line by writing to the output port register. For all user generated commands to the UART receiver, like enable RX, disable RX or set break, the user must set the associated $\overline{\text{RTS}}$ signal by writing the OP0 or OP1 register. But the UART receiver automatically deasserts the $\overline{\text{RTS}}$ signal if the number of received data words reached the FIFO alarm level and deasserts the $\overline{\text{RTS}}$ line if the number of words in the FIFO falls under the granularity level.

After the stop bit is detected, the receiver immediately looks for the next start bit.

- If a non-zero character is received without a stop bit (framing error) and RxD remains low for one-half of bit period after stop bit is sampled, the receiver operates as if a new start bit were detected. Parity error (PE), framing error (FE), overrun error (ORERR), and received break (RB) conditions set respective error and break flags in SR at the received character boundary and are valid only if SR[RxRDY] is set.
- If a break condition is detected (RxD is low for the entire character including the stop bit), a character of all 0s is loaded into the Receiver Shift Register and SR[RB,RxRDY] are set. RxD must return to a high condition for at least one-half bit-time before a search for the next start bit begins.

The receiver will detect the beginning of a break in the middle of a character, if the break persists through the next character time.

- If the break begins in the middle of a character, the receiver places the damaged character in the Rx FIFO stack and sets the corresponding SR error bits and SR[RxRDY].
- If the break lasts until the next character time, the receiver places an all-0 character into the Rx FIFO and sets SR[RB,RxRDY].

### 15.3.1.5 Configuration Sequence for UART Mode

Table 15-54 shows the configuration sequences. This list includes the UART mode related registers only, not the other configure values like interrupt and FIFO configurations. PSC module registers can be accessed by word or byte operations.

**Table 15-54. General Configuration Sequence for UART mode**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| CSR | 0xdd00 | select the clock source |
| SICR | 0x00000000 or 0x08000000 | Select the UART mode |
| MR1 | 0xXX | Select Error Mode, Parity Mode and the Parity Type |
| MR2 | 0xXX | Select Channel Mode, Port Control and Stop-Bit Length |
| CTUR | 0x00 | set the Baud rate to 9600 with IPB clock frequency 66 MHz |
| CTLR | 0xD7 | |
| RFALARM | 0x0XXX | Choose Rx FIFO “almost full” threshold level. |
| TFALARM | 0x0XXX | Choose Tx FIFO “almost empty” threshold level. |
| IMR | 0xXXXX | select the desired interrupt |
| Port_Config | 0x00000005 | Select the Pin-Muxing for UART mode for PSC1, see Chapter 2, “Signal Descriptions” |
| CR | 0x05 | Enable Tx and Rx |

### 15.3.2 PSC in Codec Mode

After reset all PSCs are in UART mode. PSC1,2,3 and 6 can be put to one of the Codec modes by writing the appropriate value to the SICR register. The other values should be initialized at the same time. During Codec mode the PSC can connect to Codec interfaces with 8, 16, 24 or 32 bit data. For all these modes the PSC can be programmed to behave as a “normal soft modem” interface, SPI, ESAI, or $I^2S$ interface. The PSC Codec supports for all these modes the master mode (PSC drive the BitClk and FrameSync signal) or slave mode (PSC receive the BitClk and FrameSync signals) functionality. Independently from the mode (master or slave) the PSC can provide an Mclk (master clock) for an external Codec device. This behavior eliminates the need for an external crystal for the external Codec device. Figure 15-73 shows a simplified block Diagram for the PSC Codec mode. The Chapter 2, “Signal Descriptions” shows only the PSC signal names for the “normal” Codec mode. Table 15-55 shows the signal assignment for all PSC Code modes.

**Table 15-55. Signal Definition for all Codec Modes**

| Mode | Signal Name | | | |
|---|---|---|---|---|
| “normal” Codec ESAI | TXD | RXD | CLK | FrameSync |
| $I^2S$ | SDATA_out | SDATA_in | SCK | LRCK |
| SPI Master | MOSI | MISO | SCK | SS |
| SPI Slave | MISO | MOSI | SCK | SS |

The important register to configure the PSC for Codec mode are:

- SICR register — select the Codec mode
- for master mode:
  - cdm_pscX_bitclk_config — select Mclk frequency, see Section 5.5.1.11, “PSC1 Mclock Configuration Register”
  - cdm_clock_enable_register- enable Mclk, see Section 5.5.1.6, “CDM Clock Enable Register”
  - CCR — select BitClk and FrameSync Frequency
  - CTUR — select FrameSync width
- RFALARM, TFALARM — select the FIFO “Alarm” level
- CR register — enable or disable receiver and transmitter
- Port_config — select the right Pin-Muxing, Chapter 2, “Signal Descriptions”

### 15.3.2.1 Block Diagram and Signal Definition for Codec Mode

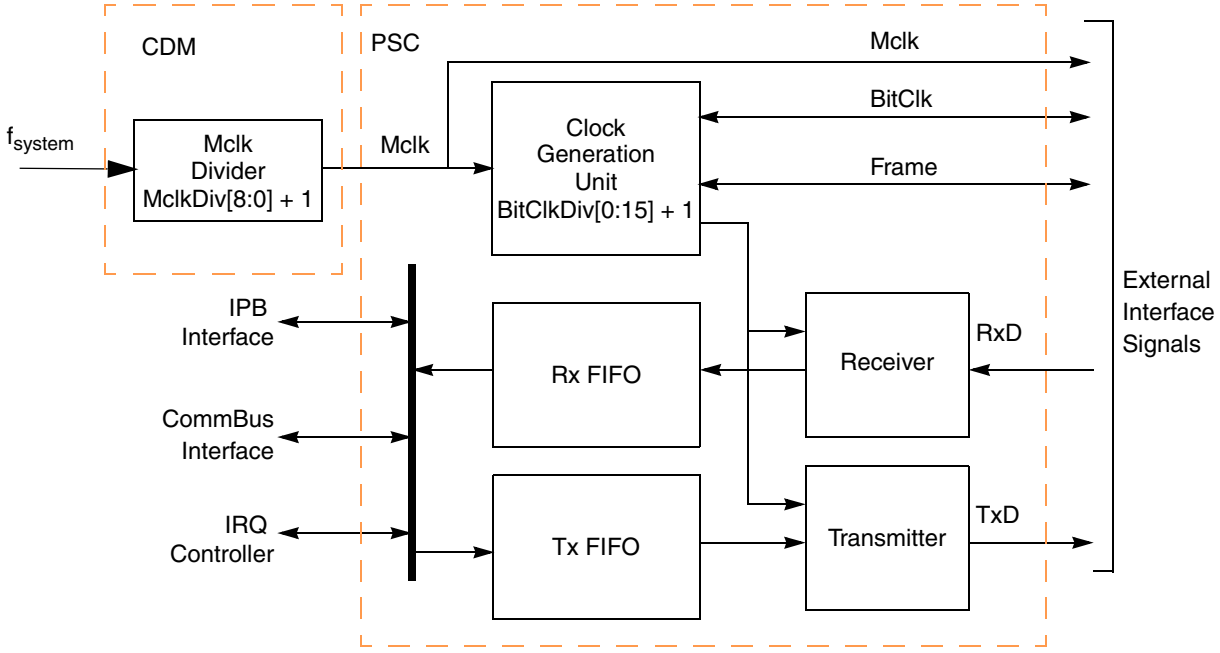



**Figure 15-73. PSC Codec Block Diagram**

**NOTE**

Here is important difference between PSC6 and the other PSCs. To work with PSC6 in slave mode (CODEC slave, SPI slave), the ext_48MHz_en bit in the cdm_48mhz_fractional_divider_configuration register must be set to one. If this bit was set to zero then the internal 48 Mhz clock generator drive the clock line. For more informations see Section 5.5.1.5, “CDM 48MHz Fractional Divider Configuration Register.”

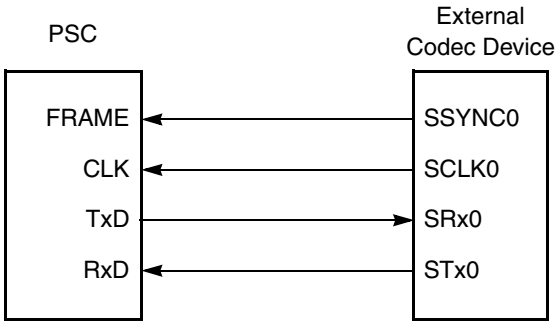



**Figure 15-74. PSC Codec Interface in Slave Mode**

**Table 15-56. PSC Signal Description for Codec Mode**

| Signal | Description |
|---|---|
| TxD | Transmitter Serial Data Output—Data is shifted out on TxD on the falling or rising edge of the clock source. Transfers can be specified as either lsb or msb first. TxD is held low when Tx is disabled or idle.<br>Data shifted out on the rising edge of CLK if SICR[ClkPol] = 0<br>Data shifted out on the falling edge of CLK if SICR[ClkPol] = 1<br>and<br>Data send msb first if SICR[SHDIR] = 0<br>Data send lsb first if SICR[SHDIR] = 1 |
| RxD | Receiver Serial Data Input—Data received on RxD is sampled on the falling or rising edge of the clock signal. Transfers can be specified as either lsb or msb first.<br>Data sampled on the rising edge of CLK if SICR[ClkPol] = 1<br>Data sampled on the falling edge of CLK if SICR[ClkPol] = 0<br>and<br>Data sampled msb first if SICR[SHDIR] = 0<br>Data sampled lsb first if SICR[SHDIR] = 1 |
| Frame | Frame Sync—In Codec mode Frame can be driven from an external Codec or can be generate by the internal clock logic. Frame can be programmed as active High or active Low.<br>The frame sync input from the external Codec if SICR[GenClk] = 0<br>The frame sync output to the external Codec if SICR[GenClk] = 1<br>and<br>Frame sync is active low if SICR[SyncPol] = 0<br>Frame sync is active high if SICR[SyncPol] = 1 |
| CLK | Bit Clock— In Codec mode CLK is:<br>• The clock input from the external Codec if SICR[GenClk] = 0<br>• The clock output to the external Codec if SICR[GenClk] = 1 |
| Mclk | Clock output for an external Codec |

### 15.3.2.2 Codec Clock and FrameSync Generation

The serial BitClk and the FrameSync can either be inputs that come from an external Codec device, or they can be internally generated by the PSC and provided as outputs to the external device, under control of bit SICR[GenClk]. When the bit SICR[GenClk] is set to zero then the BitClk and the FrameSync are inputs. In this case the FrameSync width can be anything from one BitClk period up to the total FrameSync length/period minus one BitClk. If the GenClk bit set to one, then the MPC5200 PSC generate the BitClk and the FrameSync signal. Figure 15-75 shows how the PSC generate the clocks.

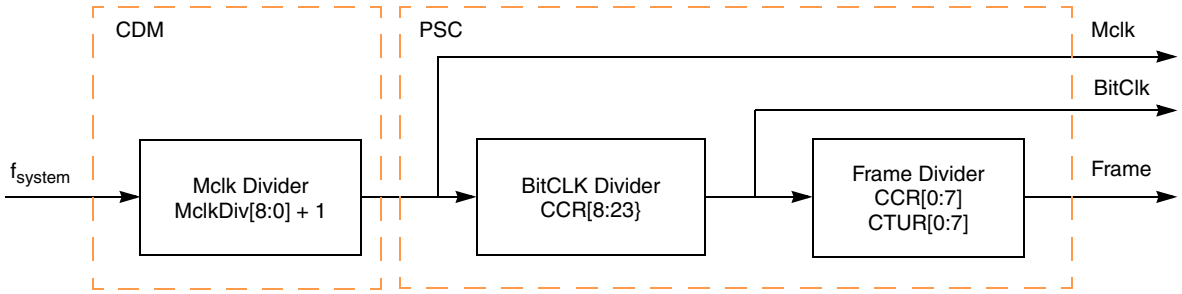



**Figure 15-75. Clock Generation Diagram for Codec Mode**

The source for the internal clock generation is the MclkDiv clock divider in CDM module. The CDM provides for each Codec PSC (1, 2, 3 and 6) a separate Mclk and MclkDiv clock divider. For more information about the $f_{system}$ clock see also Section 5.5.1.11, "PSC1 Mclock Configuration Register." The PSC provides the clock to the external Codec divided independently whether the PSC configured as a master (provide BitClk and FrameSync) or as a slave (receive the clock signals). These dividers generate the Mclks by dividing the $f_{system}$ clock as follows:

$$\text{Mclk} = \frac{f_{system}}{\text{MclkDiv [8:0] +1}}$$

Each PSC consists of an CCR register to generate a BitClk and a FrameSync signal. If the PSC is configured as a master and all necessary register (cdm_pscX_bitclk_config and CCR) are set to the right value the PSC generate both clock signals independent if the transmitter or receiver is enabled or not. As opposed to the SPI behavior. The equations below shows the calculation:

$$\text{BitClk} = \frac{\text{Mclk}}{\text{BitClkDiv[0:15] +1}}$$

$$\text{FrameSync Length} = \text{Frame SyncDiv[0:7] + 1}$$

When the FrameSync is an output the pulse width can programmed by the register CTUR. This register defines the number of BitClk cycle during the FrameSync signal is active. The default reset value for this register is 0x00 therefore the default FrameSync width is one BitClk. See the calculation below:

$$\text{Frame sync width} = \text{CTUR[0:7] + 1}$$

### 15.3.2.3 Transmitting and Receiving in “Soft Modem” Codec Mode

The PSC supports the full duplex “soft modem” mode. Data can be received and transmitted at the same time. To start the full duplex transmission, the Tx and the Rx must be enable by writing the according value to the CR register. Also it’s possible to use only the receiver. For this case only the Rx enable bit in the CR register must be set to one. But it’s **not** possible to use the transmitter without the receiver. To transmit data only, the receiver must be enabled. The received data and the according status and interrupt bits can be ignored.

If the receiver is enabled, the PSC samples data from the receive line after detecting the start of frame condition. The receiver converts the serial data from the RX line to parallel data words and write the data to the RxFIFO. The data word length is depend on the programmed word length. If are no data on the Rx line the receiver writes zeros to the RxFIFO until the data word width was reached. The receiver waits until the next start of frame condition was detected. The transmitter converts the parallel data from the TxFIFO to a serial data stream on the TX line. If the TxFIFO is empty during the transmit state, the Tx line will be zero. If the last bit of the data word was send then the transmitter waits until the next start of frame condition was detected.

When SICR[GenClk] = 1 then the PSC is in master mode and generate the BitClk and the FrameSync signal from the internal clock system, like described in Section 15.3.2.2, “Codec Clock and FrameSync Generation.”

Figure 15-76 shows a Codec interface diagram example for “Soft Modem” master mode. The different parameter to define the interface are follows:

- Frame Sync Polarity SICR[SyncPol], the leading edge is defined as a rising edge if bit SICR[SyncPol] = 1, or a falling edge if SICR[SyncPol] = 0
- BitClk Polarity SICR[ClkcPol], when bit SICR[ClkPol] = 0 data is shifted out on the rising edge of bit clock and sampled on the falling edge of BitClk otherwise data is shifted out on the falling edge and sampled on rising edge of bit clock
- FrameSync width CTUR, define the number of BitClk during the FrameSync is active
- FrameSync length CCR[FrameSyncDiv], define the number of BitClk until the next frame starts
- Data length SICR[SIM], define the data with of the receive and transmit data, 8, 16,24 or 32 bit per word are possible, in Codec 24 mode each 24-bit data sample uses an entire 32-bit longword in the Tx FIFO. The least significant (right-hand) byte is not used, data should be written to the Tx FIFO four bytes at a time.
- Delay of time slot 1 SICR[DTS1], the PSC starts to send a sample at either the leading edge of FrameSync SICR[DTS1] = 0, or 1 bit-clock cycle after the leading edge of FrameSync SICR[DTS1] = 1
- Data shift direction SICR[SHDIR], data shifted out LSB first if SICR[SHDIR] = 1 otherwise data shifted out MSB first if SICR[SHDIR] = 0

In the Codec “Soft Modem” mode the PSC send only one data word per frame.

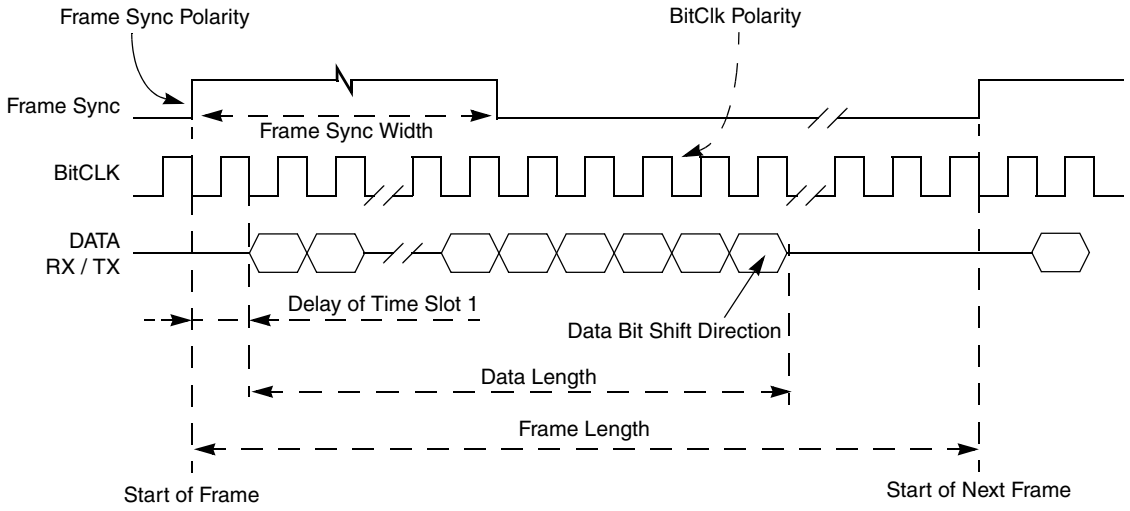



**Figure 15-76. "Soft Modem" Codec interface Diagram**

Table 15-57 shows an example how to configure the PSC1 as:

- PSC in Slave mode
- 16 bit "soft modem" mode
- Data are sampled on the falling edge of BitClk
- FrameSync is low true
- MSB first, transfer starts with leading edge of FrameSync
- set the TFALARM level to 0x010, alarm occurs if 16 byte are in the TxFIFO
- set the RFALARM level to 0x00C, alarm occurs if 12 byte space in the RxFIFO
- enable TxRDY interrupt

**Table 15-57. 16-Bit "Soft Modem" Slave Mode**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x0210_0000 | Select the 16 bit Codec mode, msb first, DTS1 = 0, slave mode |
| RFALARM | 0x000C | set the RFALARM level to 0x00C |
| TFALARM | 0x0010 | set the TFALARM level to 0x010 |
| IMR | 0x0100 | enable TxRDY interrupt |
| Port_Config | 0x0000_0006 | Select the Pin-Muxing for PSC1 Codec mode, see Chapter 2, "Signal Descriptions" |
| CR | 0x05 | Enable Tx and Rx |

Table 15-58 shows an example how to configure the PSC2 as:

- PSC in Master mode
- 32bit “soft Modem” mode
- Data are sampled on the rising edge of BitClk
- FrameSync is low true
- lsb first, transfer starts one cycle after the leading edge of FrameSync
- Set Mclk frequency to 33 MHz
- Set Bitclk frequency to 250 kHz
- FrameSync every 35 BitClk
- Set FrameSync width to 3 BitClk
- Set the TFALARM level to 0x010, alarm occurs if 16 bytes are in the TxFIFO
- Set the RFALARM level to 0x00C, alarm occurs if 12 bytes space in the RxFIFO
- Enable TxRDY interrupt

**Table 15-58. 32-Bit “Soft Modem“Master Mode**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x3FA0_0000 | Select the 32bit Codec mode, lsb first, DTS1 = 1, master mode |
| cdm_psc2_bitclk_config | 0x800F | divide the $f_{system}$ clock frequency from 528 to 33MHz Mclk, see Section 5.5.1.12, “PSC2 Mclock Configuration Register” |
| cdm_clock_enable_register | 0x0000_0040 | enable Mclk, see Section 5.5.1.6, “CDM Clock Enable Register” |
| CCR | 0x2283_0000 | select the BitClk and FrameSync frequency |
| CTUR | 0x02 | select the FrameSync width |
| RFALARM | 0x000C | set the RFALARM level to 0x00C |
| TFALARM | 0x0010 | set the TFALARM level to 0x010 |
| IMR | 0x0100 | enable TxRDY interrupt |
| Port_Config | 0x0000_0070 | Select the Pin-Muxing for PSC2 Codec mode, Mclk output enabled, see Chapter 2, “Signal Descriptions” |
| CR | 0x05 | Enable Tx and Rx |

### 15.3.2.4 Transmitting and Receiving in ESAI Mode (Enhanced Serial Audio Interface)

The ESAI transmission is similar to the “Soft Modem” mode. Therefore the configuration is the same like described in Section 15.3.2.3, “Transmitting and Receiving in “Soft Modem” Codec Mode.” The different is, that the ESAI protocol allow to transmit and receive more than one data word per frame. To enable the ESAI mode the SICR[ESAI] bit must be set. The PSC calculate how many data words the transmitter will send and how many data the receiver will expect. Figure 15-77 shows the ESAI transmission diagram.

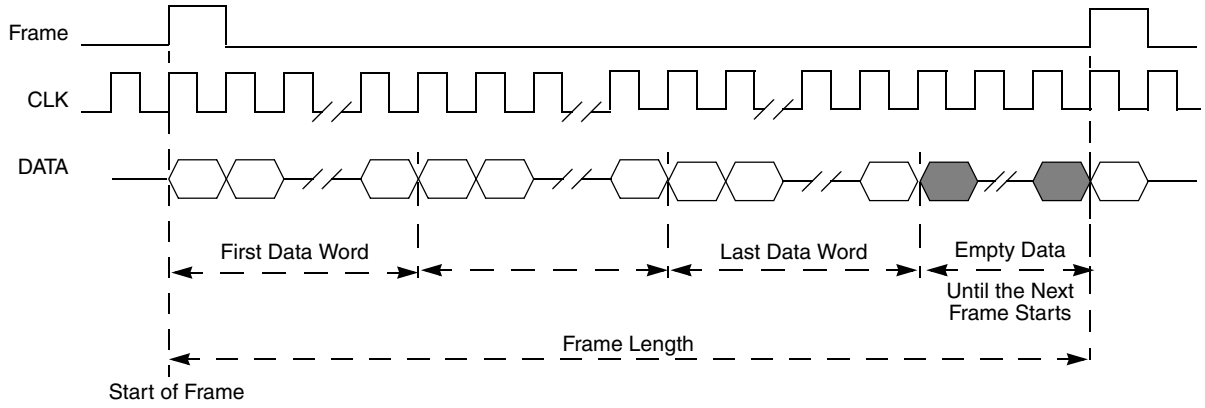



**Figure 15-77. ESAI Data Transmission**

Table 15-58 shows an example how to configure the PSC1 as ESAI master. For the slave mode the bit ICR[GenClk] must be cleared and the configuration of the CCR register can be ignored. In this configuration example the PSC will send 3 data words with 16 bit data in the 52 BitClk frame length. The last four bits in the frame will be empty (zero).

- Use PSC1 as ESAI master
- 16 bit data, LSB first
- BitClk frequency 4 MHz
- FrameSync length 52 bit
- Data shifted out on the rising edge of BitClk
- Data transfer starts on FrameSync is active
- FrameSync is active high
- Set the TFALARM level to 0x010, alarm occurs if 16 byte are in the TxFIFO
- Set the RFALARM level to 0x00C, alarm occurs if 12 byte space in the RxFIFO
- Enable TxRDY interrupt

**Table 15-59. 16-bit ESAI Master Mode for PSC1**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x12D2_0000 | Select the 16bit Codec ESAI master mode, LSB first, DTS1=0 |
| cdm_psc1_bitclk_config | 0x8020 | Divide the $f_{system}$ clock frequency from 528 to 16 MHz Mclk, see Section 5.5.1.11, “PSC1 Mclock Configuration Register” |
| cdm_clock_enable_register | 0x0000_0020 | Enable Mclk, see Section 5.5.1.6, “CDM Clock Enable Register” |
| CCR | 0x3303_0000 | Set the FrameSync length (52 bit) and SCKL frequency |
| RFALARM | 0x000C | Set the RFALARM level to 0x00C |
| TFALARM | 0x0010 | Set the TFALARM level to 0x010 |
| IMR | 0x0100 | Enable TxRDY interrupt |
| Port_Config | 0x0000_0006 | Select the Pin-Muxing for PSC1 Codec mode, see Chapter 2, “Signal Descriptions” |
| CR | 0x05 | Enable Tx and Rx |

### 15.3.2.5 Transmitting and Receiving in “Cell Phone” Mode

The transmission protocol for the “Cell Phone” mode is the same like in the “Soft Modem” mode. The PSC use the configure and clock generation registers is the same as described in the section before, see Section 15.3.2.3, “Transmitting and Receiving in “Soft Modem” Codec Mode.” The goal for this mode is, that PSC2, 3 or 6 can generate a BitClk which is synchronous to in the BitClk input on PSC1. Only the internal clock distribution is different to the “Soft Modem” mode. The major deviation is, that the “Cell Phone” slave PSCs use the clock from PSC1 for BitClk and FrameSync generation instead of Mclk from the CDM module.

PSC1 is the only PSC that can work as “Cell Phone” master, PSC2, 3 or 6 are available as “Cell Phone” slave. The “Cell Phone” master PSC must be configured as codec slave, this means that the PSC1 receive the BitClk from the outside. Therefore the SICR[GenClk] bit must be cleared. The “Cell Phone” slave PSCs must be configured as codec master. Therefore the SICR[GenClk] must be set and the FrameSyncDiv and BitClkDiv values in the CCR register must be set to the desired value, like described in Section 15.3.2.2, “Codec Clock and FrameSync Generation.” To enable the “Cell Phone” slave functionality the SICR[CellSlave] bit must set. If this bit was set the PSCs use the BitClk from PSC1 for the internal clock generation instead of the Mclk. If the SICR[CellSlave] and the SICR[Cell2xClk] bit was set, then the “Cell Phone” salve PSCs use the BitClk from PSC1 multiplied by 2 for the internal clock generation. The incoming PSC1 BitClk must be faster than $f_{system}/512$, to make sure that the internal clock doubler works fine. If the PSC1 BitClk is smaller than $f_{system}/512$ then the Cell2xClk feature is not usable. These facts are described in Figure 15-78

Table 15-60 and Table 15-61 shows an example how to configure the PSC system as follows:

- PSC1 is “Cell Phone” master, PSC2 works as “Cell Phone” slave
- Both PSC work with 24bit data
- Data are sampled on the falling edge of BitClk
- FrameSync is high true
- MSB first, transfer starts on the leading edge of FrameSync
- PSC2 us the BitClk from PSC1 multiplied by 2 for clock generation
- FrameSync every 24BitClk, for both PSCs
- Set FrameSync width to 1 BitClk
- Set the TFALARM level to 0x010, alarm occurs if 16 byte are in the TxFIFO
- Set the RFALARM level to 0x00C, alarm occurs if 12 byte space in the RxFIFO
- Enable TxRDY interrupt

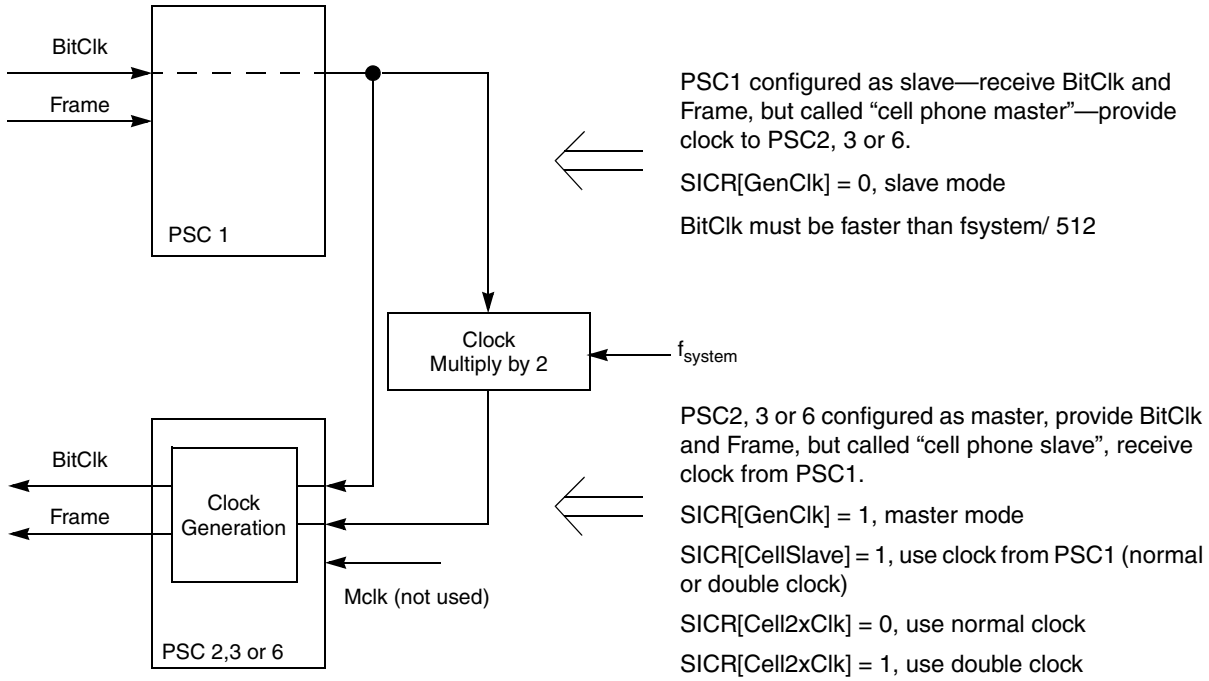

BitClk
Frame
PSC 1
PSC1 configured as slave—receive BitClk and Frame, but called “cell phone master”—provide clock to PSC2, 3 or 6.
SICR[GenClk] = 0, slave mode
BitClk must be faster than fsystem/ 512
Clock Multiply by 2
fsystem
BitClk
Frame
Clock Generation
Mclk (not used)
PSC 2,3 or 6
PSC2, 3 or 6 configured as master, provide BitClk and Frame, but called “cell phone slave”, receive clock from PSC1.
SICR[GenClk] = 1, master mode
SICR[CellSlave] = 1, use clock from PSC1 (normal or double clock)
SICR[Cell2xClk] = 0, use normal clock
SICR[Cell2xClk] = 1, use double clock

**Figure 15-78. Clock Distribution Network in Cell Phone Mode**

**Table 15-60. 24-Bit Cell Phone Master Mode for PSC1**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x0710_0000 | Select the 24bit Codec mode, msb first, DTS1 = 0, slave mode |
| RFALARM | 0x000C | Set the RFALARM level to 0x00C |
| TFALARM | 0x0010 | Set the TFALARM level to 0x010 |
| IMR | 0x0100 | Enable TxRDY interrupt |
| Port_Config | 0x0000_0066 | Select the Pin-Muxing for PSC1,PSC2 Codec mode, see Chapter 2, “Signal Descriptions: |
| CR | 0x05 | Enable Tx and Rx |

**Table 15-61. 24-Bit Cell Phone Slave Mode for PSC2**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x0798_0000 | Select the 24bit Codec mode, msb first, DTS1 = 0, master mode, cell phone master |
| CCR | 0x0117_0000 | Select the BitClk and Frame frequency |
| CTUR | 0x00 | Select the FrameSync width, default value |
| RFALARM | 0x000C | Set the RFALARM level to 0x00C |
| TFALARM | 0x0010 | Set the TFALARM level to 0x010 |
| IMR | 0x0100 | Enable TxRDY interrupt |
| Port_Config | 0x0000_0066 | Select the Pin-Muxing for PSC12, PSC2 Codec mode, see Chapter 2, “Signal Descriptions” |
| CR | 0x05 | Enable Tx and Rx |

### 15.3.2.6 Transmitting and Receiving in I$^2$S Master Mode

The next support mode is the I$^2$S mode. The I$^2$S transmission is similar to the “Soft Modem” mode. Therefore the configuration is the same like described in Section 15.3.2.3, “Transmitting and Receiving in “Soft Modem” Codec Mode.” The different is, that during the I$^2$S word transmission the FrameSync signal (LRCK) is stable for the complete data word and is the opposite for the next one. To enable the I$^2$S mode the SICR[I2S] bit must be set. The SICR[SyncPol] bit define if the frame starts with a low LRCK signal or with a high LRCK signal. If the transmitter detect the start condition he starts to send the data from the TxFIFO. If the receiver detects an start condition, he starts to write the data from the RX line to the RxFIFO. The FIFO doesn’t provide the ability to mark the data in the FIFO, therefore only the order in the FIFO define if the data was receive/transmit during high or low phase of the LRCK. Figure 15-79 shows the I$^2$S transmission diagram.

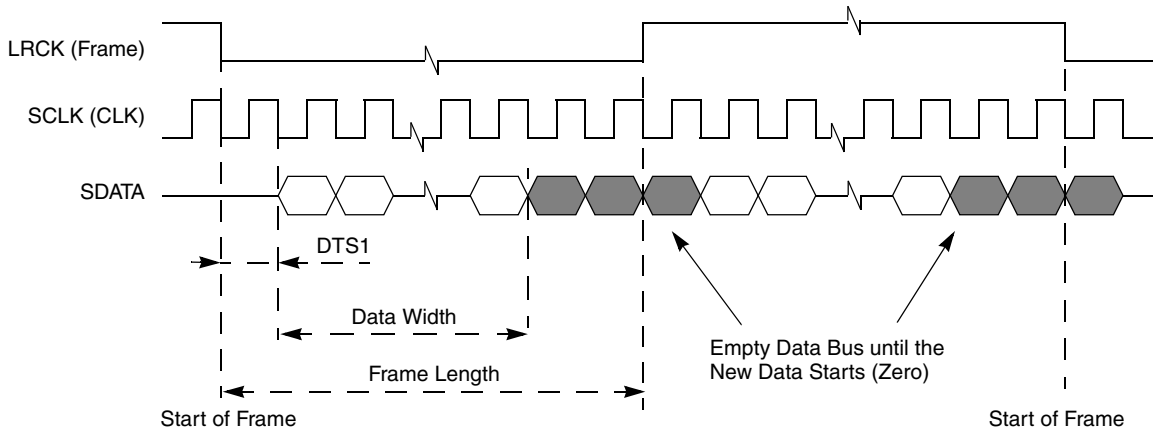



**Figure 15-79. I²S Data Transmission**

Table 15-62 shows an example how to configure the PSC1 as I²S master. For the slave mode the bit SICR[GenClk] must be cleared and the configuration of the CCR register can be ignored.

- Use PSC1 as I²S master
- 32 bit data, MSB first
- SCLK frequency 1 MHz
- FrameSync width 40 bit
- Data shifted out on the falling edge of SCLK
- Data transfer starts one CLK cycle after the FrameSync is active
- Frame starts with LRCK low
- Set the TFALARM level to 0x010, alarm occurs if 16 byte are in the TxFIFO
- Set the RFALARM level to 0x00C, alarm occurs if 12 byte space in the RxFIFO
- enable TxRDY interrupt

**Table 15-62. 32-bit I²S Master Mode for PSC1**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x2FE00000 | Select the 32bit Codec I²S master mode, msb first, DTS1 =1 |
| cdm_psc1_bitclk_config | 0x8020 | Divide the $f_{system}$ clock frequency from 528 to 16 MHz Mclk, see Section 5.5.1.11, “PSC1 Mclock Configuration Register” |
| cdm_clock_enable_register | 0x00000020 | Enable Mclk, see Section 5.5.1.6, “CDM Clock Enable Register” |
| CCR | 0x270F0000 | Set the FrameSync width (40 bit) and SCKL frequency |
| RFALARM | 0x000C | Set the RFALARM level to 0x00C |
| TFALARM | 0x0010 | Set the TFALARM level to 0x010 |
| IMR | 0x0100 | Enable TxRDY interrupt |
| Port_Config | 0x00000006 | Select the Pin-Muxing for PSC1 Codec mode, see Chapter 2, “Signal Descriptions” |
| CR | 0x05 | Enable Tx and Rx |

### 15.3.2.7 Transmitting and Receiving in SPI Mode

An other available Codec mode is the SPI mode. The PSC support a full duplex SPI interface. This mode is chosen by setting SICR[SPI] = 1, which must be true in order for the MSTR, CPOL, CPHA, and UseEOF bits in the SICR register to take effect. In SPI mode, the SICR[SIM] bits must also be set to select the data width. To configure the PSC to act like an SPI master set SICR[MSTR] = 1, or set SICR[MSTR] = 0 to configure the PSC as an SPI slave. When SICR[MSTR] bit was set then SICR[GenClk] must also be set to 1 since the PSC is driving the SPI clock line. When SICR[MSTR] = 0 then SICR[GenClk] must be set to 0 since the external SPI is driving the SCK clock line. The CPOL and CPHA bits in the SICR register operate exactly the same way as they do in an SPI, and their values must be the same as the CPOL and CPHA bits in the SPI device that is communicating with the PSC. The SICR[UseEOF] bit has an effect only when SICR[MSTR] = 1 for master mode. If the UseEOF bit is cleared then only one data word (8, 16, 24 or 32 bit width depend on the SICR[SIM] filed) will be send before Slave Select ($\overline{SS}$) goes high/inactive. When SICR[UseEOF] = 1then the number of bytes transferred prior to $\overline{SS}$ going high is controlled by the BestComm task that fills the Tx FIFO. By using the "tfdOnExit" keyword in the for-loop that fills the Tx FIFO, the last byte written into the Tx FIFO by the for-loop is marked with an EOF flag.

EOF mode is supported to enable the user to transfer an increased quantity of data in one frame. When using EOF mode the PSC reads bytes out of the Tx FIFO, the $\overline{SS}$ signal is driven low (asserted) and the SPI continues to transmit. The last data of the frame is sent after the EOF flag is set. This presence of the EOF flag shows that the last data in the frame has been reached. EOF mode should not be used for single data transfers, and is limited by data packages which must be bigger than the chosen codec size. When using EOF mode, the next data EOF frame flag should not be used to toggle the SS signal after every individual transfer when in EOF mode. If the SPI is used to transmit data in single codec size packages, the UseEOF bit in the SICR register should be cleared (0), and the value of the SIM field in this register should be set for the appropriate data transfer size.

To mark a data word with the EOF flag during an IPB transfer set the Bit IRCR2[NXTEOF] before writing the last data word to the TX FIFO. This bit will be cleared after the next write access to the TX FIFO.

The SICR[SHDIR] bit controls the shift direction in SPI mode, just as it does in the non-SPI Codec modes. The DTS1, MultiWd, ClkPol, SyncPol, CellSlave and Cell2xClk bits in the SICR register have no effect in SPI mode.

In SPI master mode the BitClk (SCK) frequency is generated by dividing down the Mclk frequency, see Section 15.3.2.2, “Codec Clock and FrameSync Generation.” Additional to the BitClk generation the DSCLK delay and the DTL delay must be defined. The DSCLK defines the delay between the $\overline{SS}$ going active and the first BitClk (SCK) clock pulse transition. The DSCLK delay is created by dividing down the Mclk frequency. The delay between consecutive transfers is created by dividing down the IPB clock frequency. For more informations about the delay generation see also the description of the CTUR, CLTR, and CCR register.

$$\text{DSCKL Delay} = \frac{\text{Mclk}}{\text{CCR[0:7]} + 1}$$

$$\text{DTL} = \frac{\text{CT[0:15]} + 2}{\text{IPB Clock Frequency}} + \frac{3}{\text{Mclk Frequency}}$$

where:
CT[0:15] = {CTUR[0:7], CTLR[0:7]}

In SPI master mode the PSC controls the serial data transfers. In this mode if either the Tx FIFO becomes empty (underrun) or the Rx FIFO becomes full (overflow) in the middle of a multi-byte transfer, rather than set the Tx underrun or Rx overflow status bits the PSC will keep the Slave Select signal low/active and stop the SCK serial clock. When the Tx FIFO doesn't become empty and the Rx FIFO becomes not full the transfer proceeds.

In SPI slave mode the Mclk must be running/enabled even though it is not being used to generate the serial clock SCK, which is provided by the external master SPI device. The frequency of Mclk is not critical, as long as it is faster than the SCK frequency.

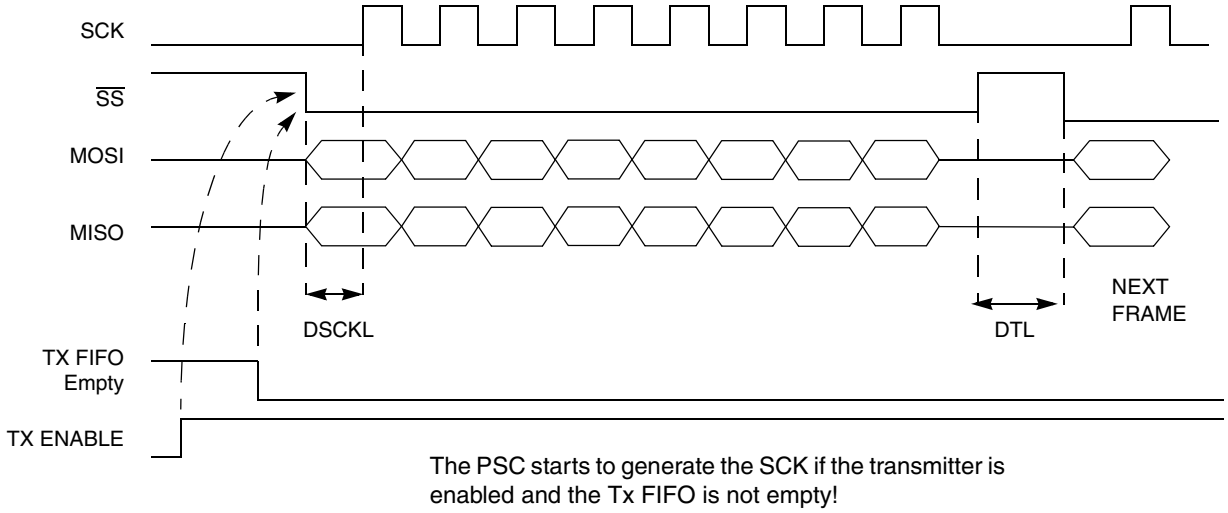



**Figure 15-80. SPI Parameter**

Table shows an example how to configure the PSC3 as SPI master.

- 32 bit data
- Clock is active high, CPOL = 0;
- The first SCK edge is issued one half cycle into the data transfer; CPHA = 0
- msb first
- Baud Rate 1MBit
- DSCLK delay = 0.5 µs
- DTL delay = 2.0 µs
- Set the TFALARM level to 0x010, alarm occurs if 16 byte are in the TxFIFO
- Set the RFALARM level to 0x00C, alarm occurs if 12 byte space in the RxFIFO

- Enable TxRDY interrupt

**Table 15-63. 32-Bit SPI Master Mode for PSC3**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x0F00C000 | Select the 32bit Codec SPI master mode, msb first, CPOL = 0,CPHA = 0 |
| cdm_psc345_bitclk_config | 0x8020 | Divide the $f_{system}$ clock frequency from 528 to 16 MHz Mclk, see Section 5.5.1.13, "PSC3 Mclock Configuration Register" |
| cdm_clock_enable_register | 0x00000080 | Enable Mclk, see Section 5.5.1.6, "CDM Clock Enable Register" |
| CCR | 0x070F | Set the SCK and DSCKL delay |
| CTUR | 0x00 | Set the DTL delay 2us |
| CTLR | 0x84 | |
| RFALARM | 0x000C | Set the RFALARM level to 0x00C |
| TFALARM | 0x0010 | Set the TFALARM level to 0x010 |
| IMR | 0x0100 | Enable TxRDY interrupt |
| Port_Config | 0x00000600 | Select the Pin-Muxing for PSC3 Codec mode, see: Chapter 2, "Signal Descriptions" |
| CR | 0x05 | Enable Tx and Rx |

Table 15-64 shows an example how to configure the PSC2 as SPI slave.

- Use PSC2 as SPI slave
- 8 bit data
- Clock is active low, CPOL = 0;
- The first SCK edge is issued at the beginning of the data transfer; CPHA = 1
- msb first
- Set the TFALARM level to 0x010, alarm occurs if 16 byte are in the TxFIFO
- Set the RFALARM level to 0x00C, alarm occurs if 12 byte space in the RxFIFO
- Enable TxRDY interrupt

**Table 15-64. 8-bit SPI Slave mode for PSC2**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x01009000 | Select the 8bit Codec SPI slave mode, msb first, CPOL = 0; CPHA = 1 |
| RFALARM | 0x000C | set the RFALARM level to 0x00C |
| TFALARM | 0x0010 | set the TFALARM level to 0x010 |
| IMR | 0x0100 | enable TxRDY interrupt |
| Port_Config | 0x00000060 | Select the Pin-Muxing for PSC2 Codec mode, see Chapter 2, "Signal Descriptions" |
| CR | 0x05 | Enable Tx and Rx |

**NOTE**

The first data transmitted and the first data received must be ignored. When the SPI slave mode is enabled, the PSC module does not generate the bit clock. The bit clock is generated by the master device and is an input to the PSC. The PSC requires several clocks for configuration of the SPI section before any data can be transferred.

The external master provides the SPI clock only when data is transmitted. Therefore, the first received and transmitted data are incorrect. The following transfers will proceed correctly.

For correct system operation, the master must send a “dummy” byte of data after each PSC-SPI configuration.

### 15.3.3 PSC in AC97 Mode

After reset all PSCs are in UART mode. AC97 mode is chosen by setting the SICR[SIM] =0x3. The other SICR field should be initialized at the same time. Only PSC1 and PSC2 support the AC97 mode. The AC97 controller supports two different AC97 modes, see Section 15.3.3.4, “Transmitting and Receiving in “legacy” AC97 Mode” and Section 15.3.3.5, “Transmitting and Receiving in “normal” AC97 Mode.” The important register to configure the PSC for AC97 mode are:

- SICR register — select the Codec mode
- RFALARM, TFALARM — select the FIFO “Alarm” level
- CR register — enable or disable receiver and transmitter
- OP0, OP1 register — generate the reset pulse for the external device
- Port_config — select the right Pin-Muxing, see Chapter 2, “Signal Descriptions”

### 15.3.3.1 Block Diagram and Signal Definition for AC97 Mode

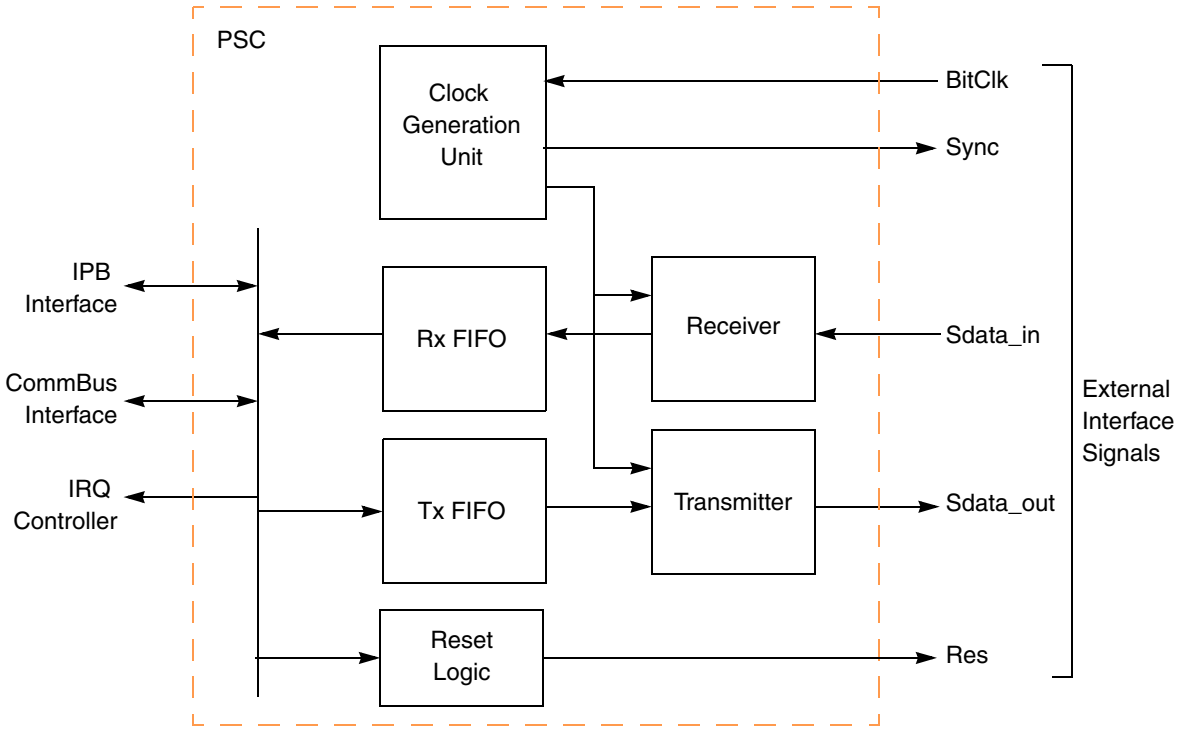



**Figure 15-81. PSC AC97 Block Diagram**

Figure 15-81 shows the simplified PSC Block Diagram for AC97 mode. The BitClk is an input from the external Codec. The PSC divide BitClk by 256 to generate a Frame pulse (Sync) that is high for 16 BitClk cycles. The PSC can only work as AC97 controller, it's means that the PSC receive the BitClk from the external AC97 codec and provide the associated Frame signal. In AC97 mode the Clock and Frame relations are fixed, therefore the CCR register and the SICR[GenClk] bit are not used. Table 15-65 shows the Pin definition for the AC97 mode and the Figure 15-82 shows an AC97 interface. An MPC5200 general-purpose I/O (GPIO) is used as a reset to the external AC97 device.

**Table 15-65. PSC Signal Description for AC97 Mode**

| Signal | Description |
|---|---|
| Sdata_out | Transmitter Serial Data Output—Data is shifted out on TxD on the rising edge of the clock signal. Transfers must be specified as msb first. |
| Sdata_in | Receiver Serial Data Input—Data received on RxD is sampled on the falling edge of the clock signal. Transfers must be specified as msb first. |
| Sync | In AC97 mode Sync is the frame sync, or start-of-frame (SOF), output to the external AC97 Controller. In this mode the AC97 BitClk, which is input on CLK, is divided by 256 to generate the Sync. |
| BitClk | BitClk— In AC97 mode CLK must be driven by the serial bit-clock from the external AC97 Controller. |
| Res | Reset signal to the external AC97 device |

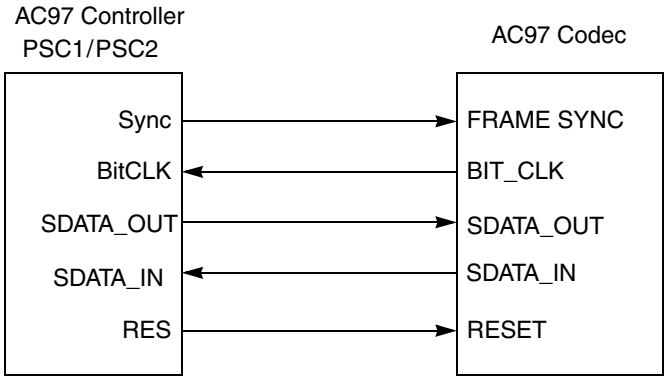



**Figure 15-82. PSC—AC97 Interface**

Figure 15-83 shows the Timing diagram for the AC97 interface. For more AC97 Controller interface information, see the *Audio Codec'97 Component Specification.*

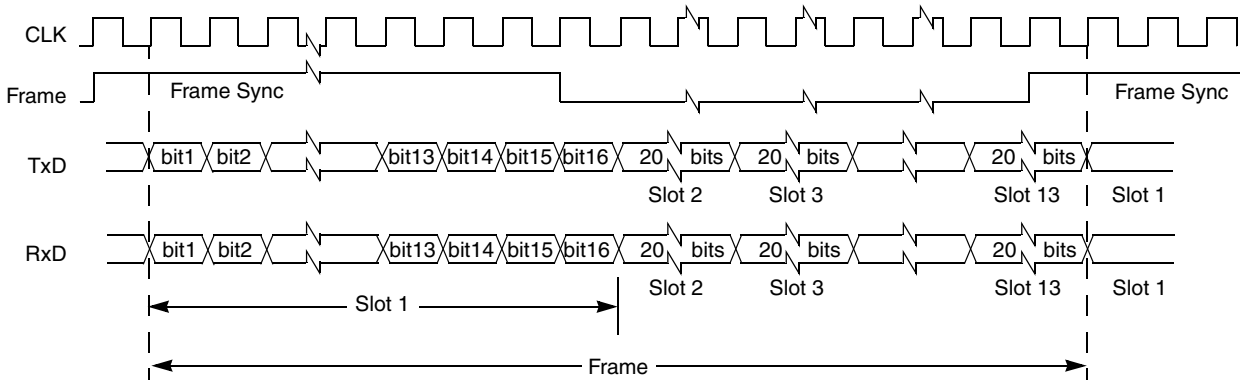



**Figure 15-83. Timing Diagram—AC97 Interface**

#### 15.3.3.2 Generate a Reset Pulse for the External AC97 Codec Device

The follow sequence generate a reset pulse for the external AC97 device:

1. $\overline{\text{Res}}$ line is high, after power up
2. write 0x02 to the OP1 register — $\overline{\text{Res}}$ line goes low
3. write 0x02 to the OP0 register — $\overline{\text{Res}}$ line goes high

**NOTE**

Some AC97 devices goes to a test mode, if the Sync line is high during the $\overline{\text{Res}}$ line is low (reset phase). To avoid this behavior the Sync line must be also forced to zero during the reset phase. To do that, the pin muxing should switch to GPIO mode and the GPIO control register should be used to control the output lines.

#### 15.3.3.3 AC97 Low-Power Mode

A General-Purpose I/O (GPIO) must be used as an AC97 reset output pin. PSC1 (or PSC2) monitors the first three time slots of each Tx frame to detect the power-down condition for the AC97 digital interface. The power-down condition is detected as follows:

1. The first 3 bits of slot 1 must be set, indicating Tx frame and slots 1 and 2 are valid.
2. Slot 2 holds the power-down register (0x26) address in the external AC97 device.
3. Slot 3 has “1” in the fourth bit (bit 12/PR4 in power-down register 1), as defined in the AC97 specification.

Low-power mode can be left through either a warm or cold reset. The CPU does a warm reset by setting SICR[AWR] for at least 1 µs. This asserts the FRAME frame sync output in AC97 mode. The CPU does a cold reset in two steps:

1. Writes 0 to whichever GPIO is being used as the active low AC97 reset pin for the minimum time specified in the AC97 specification.
2. Writes 0 to PSC1 or PSC2 SICR[ACRB]. CPU should set this bit after writing 1 to the GPIO used for the AC97 reset pin.

**NOTE**

Step 2 (above) is required so that the PSC knows when an AC97 cold reset is occurring.

### 15.3.3.4 Transmitting and Receiving in “legacy” AC97 Mode

When an AC97 Controller is specified ( SICR[SIM]=0x3), PSC1 (or PSC2) begins receiving time slot 1 data, 1 bit-clock cycle after the rising edge of frame sync, regardless of SICR[DTS1] value. However, SICR[SHDIR] must be 0, because the shift order must be msb first. The PSC divides the bit-clock by 256 to generate a frame sync pulse that is high for 16-bit clock cycles. The transmitter sends 0s until the receiver detects the Codec-ready condition (1 in the first bit of a new frame).

- Until the receiver detects the Codec ready condition (1 in the first bit of a new frame), no data is put into the Rx FIFO for that frame.
- When a Codec ready condition is detected, the receiver begins loading the Rx FIFO with the received time slot samples and continues to do so until a 0 is received in the first bit of a new frame.

Figure 15-83 shows an AC97 interface timing diagram example. Because Rx data is sampled on the falling edge of the BitClk, for transmit purposes, the frame has already started when the receiver detects a Codec-ready condition. For this reason, transmission starts at the next frame sync after the Codec-ready condition is detected. The PSC stops transmission at the end of the frame in which the first bit of the received frame is detected low (Codec not ready).

In the “legacy” AC97 mode the controller never generate or analyze the Slot0,1 and Slot3 data, expect the Codec-ready bit in Slot0. In opposite to the “normal” AC97 mode, see Section 15.3.3.5, “Transmitting and Receiving in “normal” AC97 Mode.” Therefore all data slots must be in the TxFIFO, for a complete frame must be 13 data words in the TxFIFO. The software must take sure that the data in the control slots0,1 and 2 match the value in the data slots. For each AC97 slot a 32 bit data word must be in the TxFIFO. The receiver writes 13 32 bit data words per AC97 frame to the RxFIFO.

Table 15-66 shows an example who to configure the PSC1 in AC97 mode.

**Table 15-66. General Configuration Example for “legacy” AC97 Mode**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x03000000 | Select the AC97 mode |
| RFALARM | 0x0XXX | Choose Rx FIFO “almost full” threshold level. |
| TFALARM | 0x0XXX | Choose Tx FIFO “almost empty” threshold level. |
| IMR | 0xXXXX | select the desired interrupt |
| Port_Config | 0x00000030 | Select the Pin-Muxing for AC97 mode PSC2, see Chapter 2, “Signal Descriptions” |
| CR | 0x05 | Enable Tx and Rx |

### 15.3.3.5 Transmitting and Receiving in “normal” AC97 Mode

To use PSC1 or PSC2 in “Enhanced” AC97 mode the bit SICR[EnAC97] and the SICR[SIM]=0x3 must be selected. The data transmission is the standard AC97 one, see Section 15.3.3.1, “Block Diagram and Signal Definition for AC97 Mode.” But the AC97 controller is able to generate the time slot0,1 and 2 data on the transmit site and will analyze received time slot0,1, and 2. Only during “normal” AC97 mode the

registers AC97Slots, AC97CMD, and AC97Data are used. In this mode, only the used data slots (3 to 12) are in the FIFOs.

The Rx_Slots field in the AC97Slots register specify the expected RX data slots. If the received slots doesn't match this specification the receiver will ignore all data slots from the current frame and will set the SR[UNEX_RX_SLOT] bit. Only the expected and valid tagged data slots will be in the RxFIFO. This functionality guarantees that the software can assign the data in the RxFIFO to an AC97 slot. Only the order in the RxFIFO mark the AC97 slot number.

The TX_Slots field in the AC97Slots register define, which data slots will be send. All data for these slots must be in TxFIFO. The transmitter generates the related slot0 tag data. If the TxFIFO is empty the transmitter will tag the frame as empty. The transmitter send data if the receiver detect the "Codec ready state" for the current frame, the Tx FIFO contains the specified data words (defined in the AC97Slots register) and the slot request for the specified slots was active (slot request bit was zero in the previous frame). If the AC97 Codec set a slot request to one, then the transmitter will send a complete empty frame because the transmitter is not able to send a port of the required slots without changing the order of the data in the FIFO.

If the software will send a command to the AC97 codec, the "Control Register Index" and the "Control Register Write Data" values must be written to the AC97CMD register. A write access to any word of this register will trigger the transmitter to send out the register value, synchronous the SR[CMD_SEND] bit was set. The transmitter generate a slot0 tag which mark slot1 and slot2 as valid slot. If the receiver was able to send out the command data, the SR[CMD_SEND] bit will be cleared.

If the receiver detect a valid data in time slot2, then the SR[DATA_VALID] bit was set by the receiver. The software can read the received data from the AC97Data register, synchronous the read access to this register will clear the SR[DATA_VALID] bit. If the receive detect an additional command data before the previous data was read out, the SR[DATA_OVR] bit was also set to one. The previous received command data word goes lost. A read access tot the AC97Data register will clear the SR[DATA_VALID] and SR[DATA_OVR] register. Table 15-67 shows an example how to configure the AC97 controller. In this example the AC97 controller will only send time slot 3 and slot4 data and will expect data for time slot9,10,11 and 12 on the receive site. For this purpose the software must write 2 data words to the TxFIFO for one complete AC97 frame and must read 4 data words from the RxFIFO per frame.

**Table 15-67. General Configuration Example for "normal" AC97 Mode**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x03010000 | Select the enhanced AC97 mode |
| AC97Slots | 0x0300000F | define the expected receive and transmit slots |
| RFALARM | 0x0XXX | Choose Rx FIFO "almost full" threshold level. |
| TFALARM | 0x0XXX | Choose Tx FIFO "almost empty" threshold level. |
| IMR | 0xXXXX | select the desired interrupt |
| Port_Config | 0x00000020 | Select the Pin-Muxing for AC97 mode PSC2, see Chapter 2, "Signal Descriptions" |
| CR | 0x05 | Enable Tx and Rx |

## 15.3.4 PSC in IrDA Mode

The PSC support 3 different IrDA modes. These modes are described in the follows sections.

### 15.3.4.1 PSC in SIR Mode

The SIR mode is one of the supported IrDA modes. This section will give some more informations about this mode. The imported register to configure the PSC6 (only this PSC support the IrDA modes) for SIR mode are:

- SICR register — select the SIR mode
- CTUR, CTLR register — select the Baud rate
- MR1 register — select the Receiver interrupt mode
- MR2 register — Channel Mode
- IRCR1 register — select the pulse width
- IRSDR register — select the counter for pulse width
- RFALARM, TFALARM — select the FIFO “Alarm” level
- CR register — enable or disable receiver and transmitter
- Port_config — select the right Pin-Muxing, see Chapter 2, “Signal Descriptions”

#### 15.3.4.1.1 Block Diagram and Signal Definition for SIR Mode

The Table 15-68 shows the interface signal definition. This definition is equal for all IrDA modes. The Figure 15-84. shows the PSC in SIR mode. The simplified block diagram describe the clock distribution.

**Table 15-68. Signal Description for IrDa Mode**

| Signal | Description |
|---|---|
| IRDA_TX | Transmitter Serial Data Output—Transfers must be specified as msb first. |
| IRDA_RX | Receiver Serial Data Input—Transfers must be specified as msb first. |

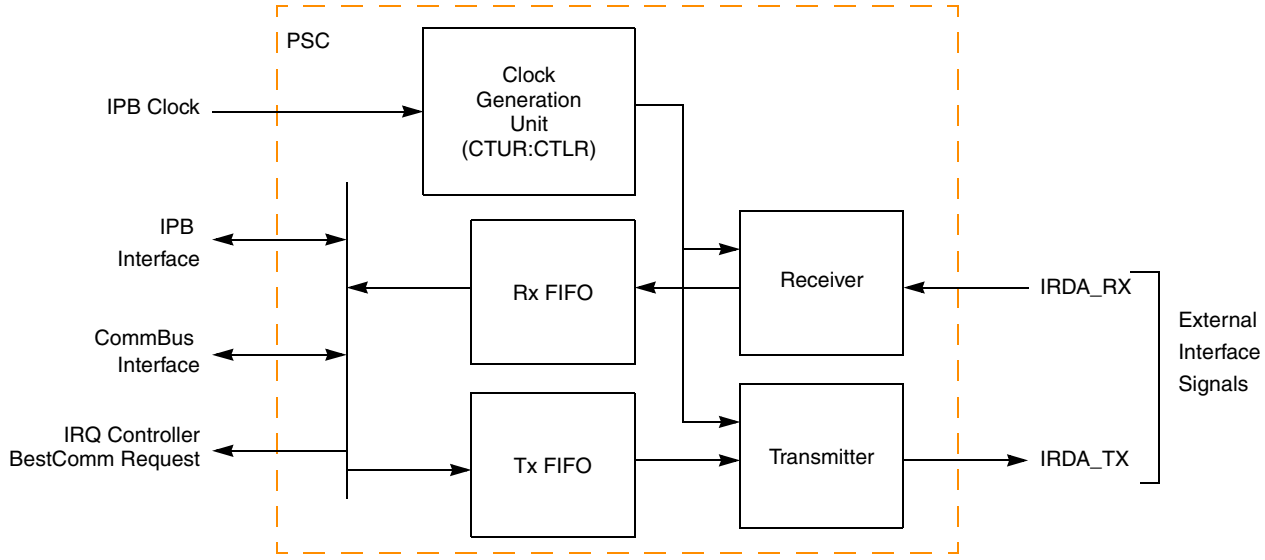



**Figure 15-84. PSC SIR Block Diagram**

### 15.3.4.1.2 Transmitting and Receiving in SIR Mode

This data format is similar to the UART. Each data consists of a start bit, 8 bits of data, and a stop bit. Each bit data is encoded so that a 0 is encoded as 3/16 of the bit time pulse (or 1.6 µs pulse) and a 1 is encoded as no pulse. Similarly, the received serial pulse is decoded as a 0 and an absence of a pulse is decoded as a 1. Like the UART mode, the SIR mode sends the lsb first. Here is an example of data stream of UART and SIR.

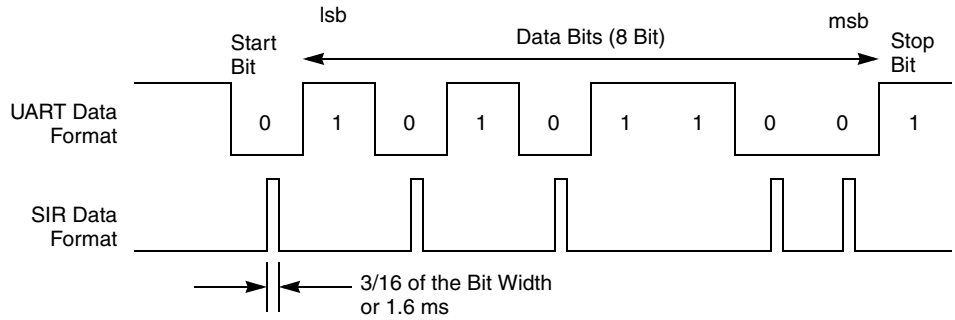



**Figure 15-85. Data Format in SIR Mode**

**NOTE**

Please choose first the desired mode (SIR mode) than configure the port (write to port_config register). This sequence will avoid pulses on the TX line during port configuration. This is very important for all IrDA (SIR, MIR, and FIR) modes.

For more informations regarding the pulse width and Baud rate calculations see Section 15.2.2.25, “Infrared SIR Divide Register (IRSDR)” and Section 15.2.2.12, “Counter Timer Upper Register (CTUR).”

#### 15.3.4.1.3 Configuration Sequence Example for SIR Mode

The Table 15-69 shows the configuration sequences. This list includes the SIR mode related registers only, not the other configure values like interrupt and FIFO configurations. PSC module registers can be accessed by word or byte operations.

**Table 15-69. Configuration Sequence Example for SIR Mode**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x04000000 | Select the SIR mode |
| IRCR1 | 0x01 | Set SIR pulse width to 1.6 ms |
| IRSDR | 0x6A | Set counter for SIR pulse width for IPB clock 66 MHz |
| CTUR | 0x00 | Set the Baud rate to 9600 with IPB clock frequency 66 MHz |
| CTLR | 0xD7 | |
| RFALARM | 0x0XXX | Choose Rx FIFO “almost full” threshold level. |
| TFALARM | 0x0XXX | Choose Tx FIFO “almost empty” threshold level. |
| IMR | 0xXXXX | Select the desired interrupt |
| Port_Config | 0x00500000 | Select the Pin-Muxing for IrDA mode, see Section 15.3.4.1, “PSC in SIR Mode” |
| CR | 0x05 | Enable Tx and Rx |

### 15.3.4.2 PSC in MIR Mode

The MIR mode is the second IrDA mode, which the PSC supports. This section will give some more informations about this mode. The important register to configure the PSC6 (only this PSC supports the IrDA modes) for MIR mode are:

- SICR register — select the MIR mode
- MR2 register — Channel Mode
- If clock generate from the internal source:
  - cdm_irda_bitclk_config — select Mclk frequency, see Section 5.5.1.14, “PSC6 (IrDA) Mclock Configuration Register”
  - cdm_clock_enable_register — enable Mclk, see Section 5.5.1.6, “CDM Clock Enable Register”
  - CCR — select BitClk and Frame Frequency
- IRCR1 register — select full duplex and SIP mode
- IRMDR register — select the clock divider
- RFALARM, TFALARM — select the FIFO “Alarm” level
- CR register — enable or disable receiver and transmitter
- Port_config — select the right Pin-Muxing, see Chapter 2, “Signal Descriptions”

#### 15.3.4.2.1 Block Diagram and Signal Definition for MIR Mode

The signal definitions for MIR mode are the same as in SIR mode. Please see Table 15-68.

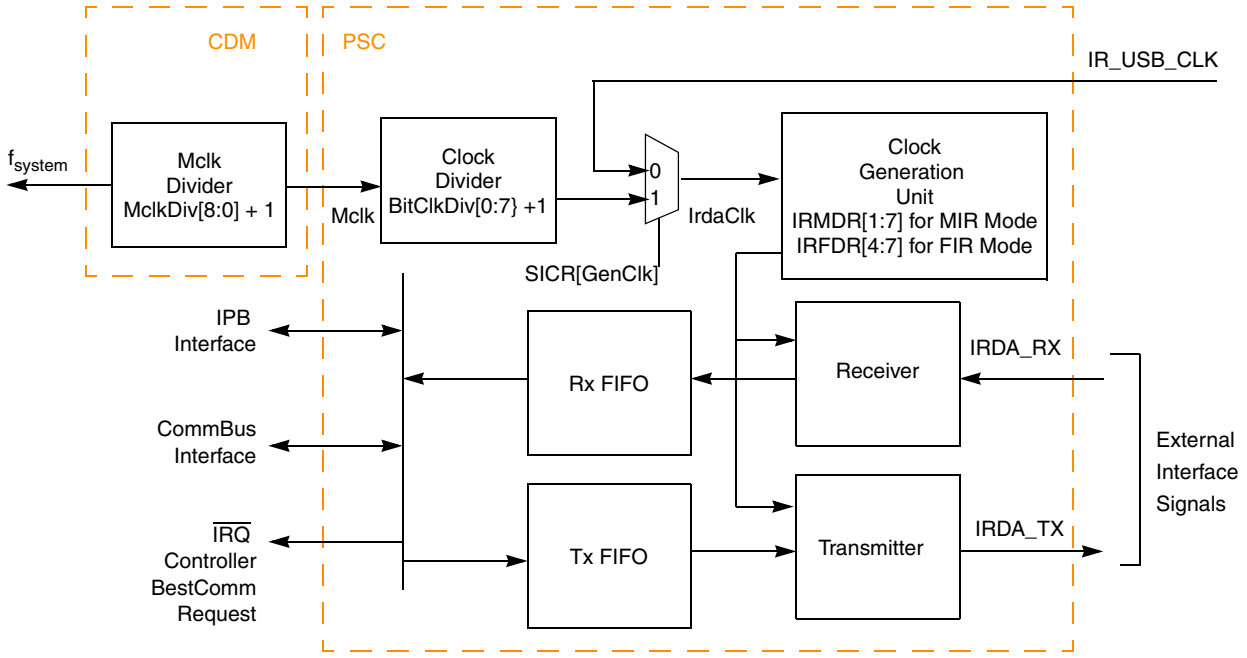



**Figure 15-86. PSC MIR and FIR Block Diagram**

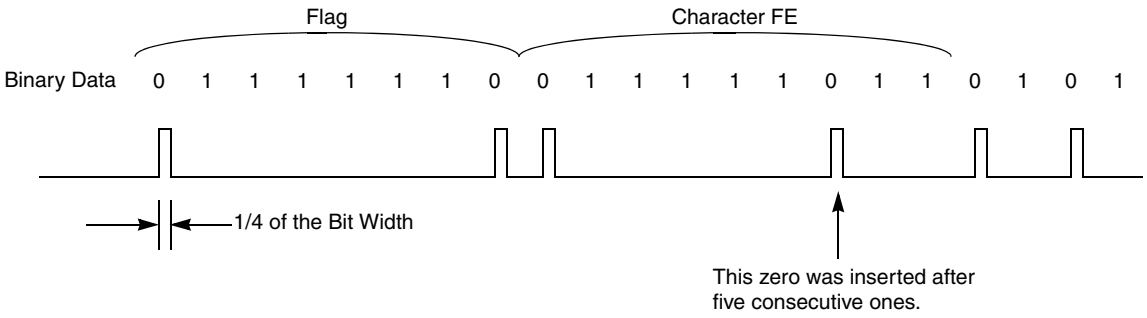
For MIR and FIR mode the clock for the transmitter and receiver is generated by dividing down from the internal Mclk or from an external clock. If the bit GenClk in the SICR was set to “1” then PSC generate the clock from the internal source. The clock from the Mclk generator goes through a pre-divider to the clock generator. See Section 15.2.2.26, “Infrared MIR Divide Register (IRMDR)” or Section 15.2.2.27, “Infrared FIR Divide Register (IRFDR)” for the possible frequencies for this mode. For more informations about the Mclk divider see Section 5.5.1.11, “PSC1 Mclock Configuration Register.” If the bit GenClk cleared then the PSC use the clock from an external source for the clock generation.

**NOTE**

If the CCR register was not changed (reset value 0x01) then the counter divide the clock (Mclk) by 2. This is the minimum value. 0x00 deactivate the clock generation.

#### 15.3.4.2.2 Transmitting and Receiving in MIR Mode

Each bit data is encoded so that a 0 is encoded as 1/4 of the bit time pulse and a 1 is encoded as no pulse. Similarly, the received serial pulse is decoded as a 0 and an absence of a pulse is decoded as a 1. The PSC MIR mode use the HDLC bit stuffing after five consecutive ones to decode/encode the data, except the STA and STO flag. For example see the Figure below:


Flag
Character FE
Binary Data
0 1 1 1 1 1 1 0 0 1 1 1 1 1 1 0 1 1 0 1 0 1
1/4 of the Bit Width
This zero was inserted after
five consecutive ones.

The packet format is:

| STA | STA | DATA | FCS | STO |
|---|---|---|---|---|
| 01111110 | 01111110 | DATA | 16 bit CRC | 01111110 |

The STA represents the start of the frame and the STO represents the end of the frame. Both of STA and STO are defined as 01111110 in binary format. Like the UART mode, the MIR mode sends the lsb first.The FCS is a 16 bit CRC defined as

$$CRC(x) = x^{16} + x^{12} + x^{5} + 1$$

**NOTE**

The MIR module doesn't support the CRC generation. If the transfer require a CRC Field use the CRC generation from the BestComm module. See also Chapter 13, "BestComm."

#### 15.3.4.2.3 Serial Interaction Pulse (SIP)

The MIR and FIR system must emit SIP (Serial Interaction Pulse) at least once per 500ms while the connection lasts, in order to inform slower systems (SIR) not to interfere the link. If the SIPEN bit in is IRCR1 high, the transmitter automatically append one SIP after every frame. SIP can be also sent by writing 1 to SIPREQ bit in IRCR2. If SIPREQ is high and the transmitter is in idle state, one SIP is sent and SIPREQ bit is automatically cleared. The SIP is defined as:

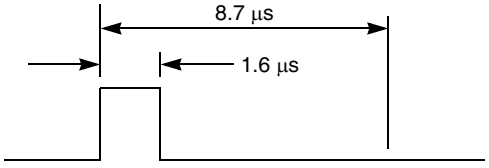



**Figure 15-87. Serial Interaction Pulse (SIP)**

#### 15.3.4.2.4 Configuration Sequence Example for MIR Mode

This list includes the MIR mode related registers only, not the other configure values like interrupt and FIFO configurations. PSC module registers can be accessed by word or byte operations. The Table 15-70 shows the configuration sequences for follow example:

- PSC6 in IrDA MIR mode
- MIR mode: 1.152 Mbps, SIP pulse after every transfer
- Mclk frequency: 27.78 MHz
- IrdaClk: 9.26 MHz

**NOTE**

Please choose first the desired mode (MIR mode) than configure the port (write to port_config register). This sequence will avoid pulses on the TX line during port configuration. This is very important for all IrDA (SIR, MIR, and FIR) modes

**Table 15-70. Configuration Sequence Example for MIR Mode**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x05800000 | Select the MIR mode, use internal clock |
| cdm_irda_bitclk_config | 0x80012 | set Mclk to 27.78 Mhz, see Section 5.5.1.11, “PSC1 Mclock Configuration Register” |
| cdm_clock_enable_register | 0x00000010 | enable Mclk, see Section 5.5.1.6, “CDM Clock Enable Register” |
| CCR | 0x0002 | set IrdaClk to 9.26 MHz |
| IRCR1 | 0x02 | enable SIP |
| IRMDR | 0x07 | set Baud rate to 1.152 Mbps |
| RFALARM | 0x0XXX | Choose Rx FIFO “almost full” threshold level. |
| TFALARM | 0x0XXX | Choose Tx FIFO “almost empty” threshold level. |
| IMR | 0xXXXX | select the desired interrupt |
| Port_Config | 0x00F00000 | Select the Pin-Muxing for IrDA mode, see Chapter 2, “Signal Descriptions” |
| CR | 0x05 | Enable Tx and Rx |

### 15.3.4.3 PSC in FIR Mode

The FIR mode is also a supported IrDA mode. This section will give some more informations about this mode. The important registers to configure the PSC6 (only this PSC support the IrDA modes) for FIR mode are:

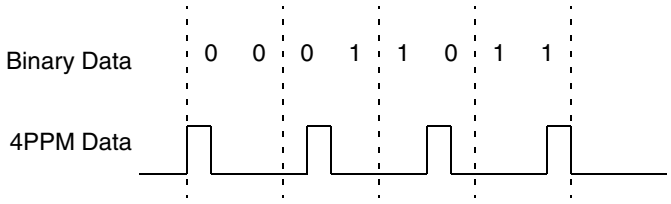
- SICR register — Select the FIR mode
- MR2 register — Channel Mode
- If clock generate from the internal source:
  - cdm_irda_bitclk_config - select Mclk frequency, see Section 5.5.1.14, “PSC6 (IrDA) Mclock Configuration Register”
  - cdm_clock_enable_register - enable Mclk, see Section 5.5.1.6, “CDM Clock Enable Register”
  - CCR — select BitClk and Frame Frequency
- IRCR1 register — full duplex and SIP mode
- IRMDR register — select the clock divider
- RFALARM, TFALARM — select the FIFO “Alarm” level
- CR register — enable or disable receiver and transmitter
- Port_config — select the right Pin-Muxing, see Chapter 2, “Signal Descriptions”

#### 15.3.4.3.1 Block Diagram and Signal Definition for FIR Mode

The signal definition for FIR mode is the same as in SIR mode. Please see Table 15-68. Figure 15-86. shows the Block diagram for FIR mode. The clock generation is the same as in MIR mode, see Section 15.3.4.2.1, “Block Diagram and Signal Definition for MIR Mode.”

#### 15.3.4.3.2 Transmitting and Receiving in FIR Mode

The data field is 4PPM encoded by the transmitter. Data encoding is done LSB first. Each chip duration is 125 ns.




| Bit Pair | 4PPM Data |
|---|---|
| 00 | 1000 |
| 01 | 0100 |
| 10 | 0010 |
| 11 | 0001 |

**Figure 15-88. Data Format in FIR Mode**

The packet format is defined as

| PA | STA | DATA | FCS | STO |
|---|---|---|---|---|

The preamble (PA) field is used by a receiver to establish phase lock. After receiving the start flag (STA), the receiver begin to interpret the 4PPM encoded symbols. The receiver continues receiving until it receives the stop flag (STO). Like the UART mode, the FIR mode sends the lsb first. For more informations regarding the pulse width and Baud rate calculations see Section 15.2.2.27, “Infrared FIR Divide Register (IRFDR).” The FCS is 32 bit CRC defined as:

$$CRC(x) = x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^{8} + x^{7} + x^{5} + x^{4} + x^{2} + x + 1$$

**NOTE**

The FIR module doesn’t support the CRC generation. If the transfer require a CRC Field use the CRC generation from the BestComm module. See also Chapter 13, “BestComm.”

The chip patterns for PA, STA, and STO are defined as:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PA | 1000 | 0000 | 1010 | 1000 | (16 times repeated) | | | |
| STA | 0000 | 1100 | 0000 | 1100 | 0110 | 0000 | 0110 | 0000 |
| STO | 0000 | 1100 | 0000 | 1100 | 0000 | 0110 | 0000 | 0110 |
| | first chip | | | | | | last chip | |

The FIR system must emit SIP (Serial Interaction Pulse), for more informations see Section 15.3.4.2.3, “Serial Interaction Pulse (SIP).”

**NOTE**

Please choose first the desired mode (FIR mode) than configure the port (write to port_config register). This sequence will avoid pulses on the TX line during port configuration. This is very important for all IrDA (SIR, MIR, and FIR) modes.

#### 15.3.4.3.3 Configuration Sequence Example for FIR Mode

The Table 15-71 shows the configuration sequences. This list includes the FIR mode related registers only, not the other configure values like interrupt and FIFO configurations. PSC module registers can be accessed by word or byte operations.

**Table 15-71. Configuration Sequence Example for FIR Mode**

| Register | Value | Setting |
|---|---|---|
| CR | 0x0A | Disable the Tx and Rx part for configuration if the PSC was enabled by the work before. |
| SICR | 0x06800000 | Select the FIR mode, use internal clock |
| cdm_irda_bitclk_config | 0x8002 | Set Mclk to 176 Mhz, see Section 5.5.1.14, “PSC6 (IrDA) Mclock Configuration Register” |
| cdm_clock_enable_register | 0x00000010 | Enable Mclk, see Section 5.5.1.6, “CDM Clock Enable Register” |
| CCR | 0x0001 | Set IrdaClk to 88 MHz |
| IRCR1 | 0x02 | Enable SIP |
| IRFDR | 0x0A | Set bit clock frequency = 8 MHZ with Mclk frequency = 88 MHz |
| RFALARM | 0x0XXX | Choose Rx FIFO “almost full” threshold level. |
| TFALARM | 0x0XXX | Choose Tx FIFO “almost empty” threshold level. |
| IMR | 0xXXXX | Select the desired interrupt |
| Port_Config | 0x00F00000 | Select the Pin-Muxing for IrDA mode, see Chapter 2, “Signal Descriptions” |
| CR | 0x05 | Enable Tx and Rx |

## 15.4 PSC FIFO System

The receive FIFO stack consists of the FIFO and a receiver shift register connected to the RxD. Data is assembled in the receiver shift register and loaded into the FIFO at the location pointed to by the FIFO Write Pointer.

Reading the Rx buffer produces an output of data from the location pointed to by the FIFO Read Pointer. After the read cycle data at the top of the FIFO stack is popped and the Rx shift register can add new data at the bottom of the FIFO. The standard FIFO Controller used in MPC5200 peripherals, such as the PSCs, was designed to control either:

- A transmit (Tx) FIFO
- A receive (Rx) FIFO

Depending on whether the FIFO is set for Tx or Rx, “Alarm” and “Granularity” are measured differently, either:

- Valid data bytes (Tx FIFO)
- Empty bytes (Rx FIFO)

For both Tx and Rx FIFOs:

- "Alarm" specifies a threshold at which the FIFO generates an interrupt to either:
  - — BestComm
  - — CPU (alternate)
- "Granularity" specifies a threshold at which the interrupt goes away.

Each PSC provide two control lines to the BestComm system, control the transfer from and to the PSC FIFO.

The FIFOs can be accessed as follows:

- 8-bit Codec mode or UART mode
  - — Can access FIFOs either 1, 2, or 4 1-Byte samples at a time.
- 16-bit Codec mode:
  - — Can access FIFOs 1 or 2  2-Byte samples at a time.
- 32-bit and 32-Bit Codec mode
  - — Can access FIFOs 4-Byte samples at a time
- AC97 mode:
  - — Must access FIFOs one sample at a time
  - — In addition, when the Rx FIFO is being read, a "1" in bit 20 (21st bit of the sample) marks this sample as the first time slot of a new frame.

Block error mode is always selected because MR1[ERR] is hard-wired high. In block mode SR shows a logical OR of all characters received after the last RESET ERROR STATUS command. Block mode offers a data-reception speed advantage where the software overhead of error-checking each character cannot be tolerated. Errors are not detected until the check is done at the end of an entire message; the faulting character is not identified.

Reading SR does not affect the FIFO. FIFO is popped only when the Rx buffer is read. If the Rx FIFO is completely full a new character is held in the Rx shift register until space is available. However, if a second new character is received, contents of the character in the Rx shift register is lost. The FIFO's are unaffected, and SR[ORERR] sets when the receiver detects the start bit of the new overrunning character.

To support flow control, the receiver can be programmed to automatically negate and assert $\overline{\text{RTS}}$. In which case, the receiver automatically negates $\overline{\text{RTS}}$ when a valid start bit is detected and the FIFO stack is full. The receiver asserts $\overline{\text{RTS}}$ when a FIFO position becomes available. Overrun errors can be prevented by connecting $\overline{\text{RTS}}$ to the $\overline{\text{CTS}}$ input of the transmitting device.

**NOTE**

The receiver can still read characters in the FIFO stack if the receiver is disabled. If the receiver is reset, the FIFO stack, $\overline{\text{RTS}}$ control, all receiver status bits, and interrupt requests are reset. No more characters are received until the receiver is re-enabled.

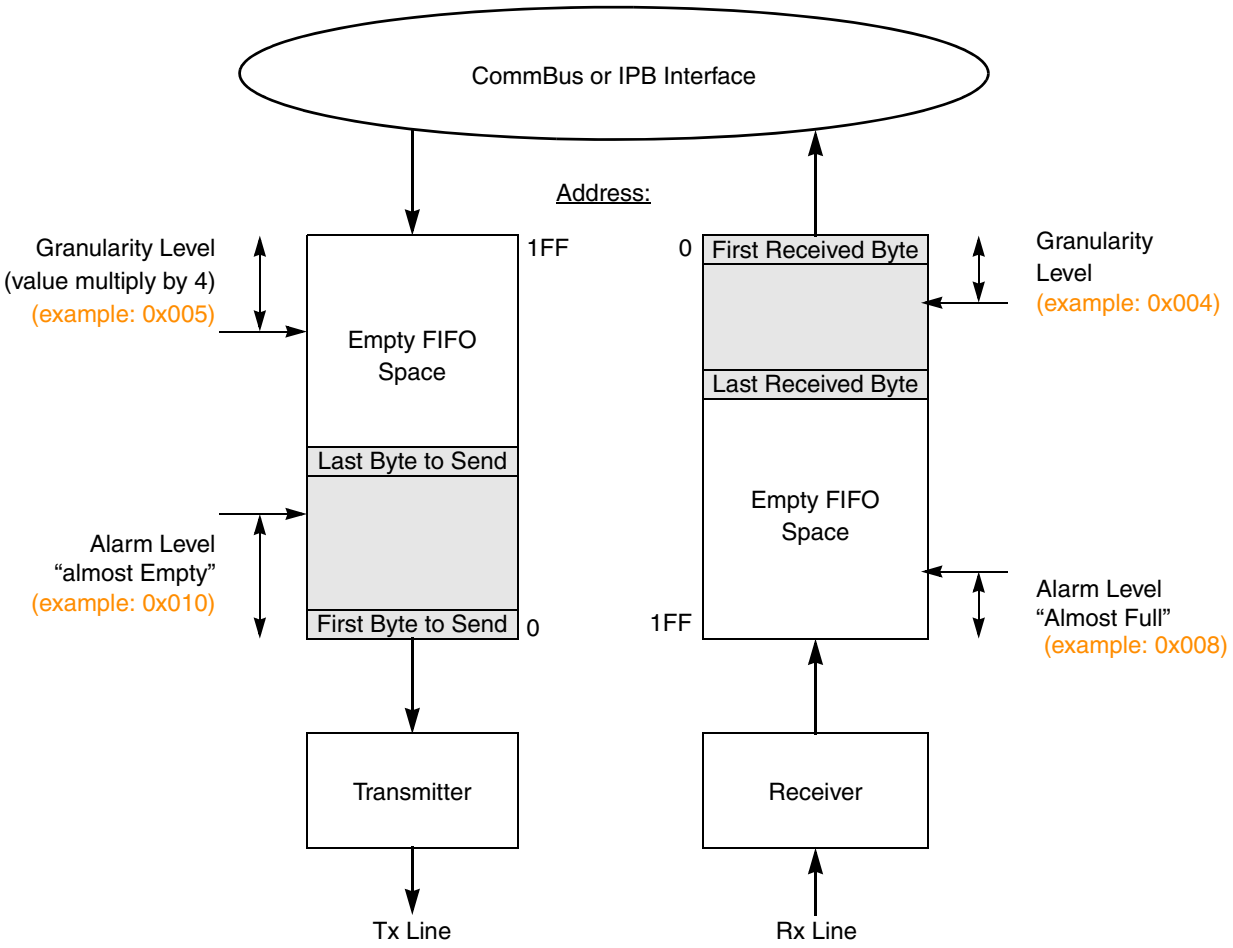



**Figure 15-89. PSC FIFO System**

## 15.4.1 RX FIFO

The RX FIFO space is 512 Byte. For an Rx FIFO, the “Alarm” value is **not** the amount of “data” in the Rx FIFO. Instead, an interrupt occurs as a result of the amount of empty space remaining in the Rx FIFO. These facts are described in Figure 15-89.

If it is known how much data is needed in the Rx FIFO to cause an interrupt, the value that must be written into the Alarm register is:

The FIFO size, minus the number of data bytes in the FIFO

Unlike the Alarm value, the Granularity value represents a number of data bytes, **not** empty space.

**NOTE**

In AC97, the number of data bytes are 4-times the number of time slot samples in the FIFO. Because, each 20-bit sample uses an entire 32-bit longword in the FIFO.

For the Rx FIFO, the value can be between 0 and 7 bytes only. Therefore, the interrupt has hysteresis. For example, the interrupt goes active when the Rx FIFO is “almost full” (i.e., amount of empty space is less than the “Alarm” level). It stays active until enough data is read out of the Rx FIFO so that the amount of data left in the FIFO is less than the “Granularity” level.

For the example (see Figure 15-89) it means:

1. The requestor to the BestComm to emptying the RX FIFO becomes active if the empty space in the FIFO is less the 8 Bytes (504 date Bytes are in the FIFO).
2. The requester became inactive if 4Bytes are left in the FIFO. (508 Byte space now)

### 15.4.2 TX FIFO

The TX FIFO space is 512 Byte. For a Tx FIFO, the “Alarm” value specifies a threshold in terms of DATA bytes, **not** in terms of empty space as with the Rx FIFO. Once the amount of data in the Tx FIFO falls below the “Alarm” level, an interrupt activates. The interrupt indicates the Tx FIFO is “almost empty” and needs more data. Tx FIFO “Granularity” is specified in terms of empty bytes, **not** a number of data bytes as with the Rx FIFO. For more informations see also Figure 15-89. The “Granularity” value range is 0–7.

The Tx FIFO controller hardware multiplies this value by 4, to establish the actual level at which the FIFO alarm goes away.

For the Tx FIFO, the alarm goes away when the number of empty bytes left in the Tx FIFO is less than or equal to:

- 0 (Granularity value 0)
- 4 (Granularity value 1)
- 8 (Granularity value 2)
- 12 (Granularity value 3)
- 16 (Granularity value 4)
- 20 (Granularity value 5)
- 24 (Granularity value 6)
- 28 (Granularity value 7)

The FIFO interrupt stays active until BestComm writes enough data into the Tx FIFO to reach the Granularity level. Once the Granularity level is reached, the interrupt goes away.

For the example (see Figure 15-89) it means:

1. The requestor to the BestComm to filling the TX FIFO becomes active if the amount of data in the FIFO is less then 16 data.
2. The requester became inactive if less than 20 (5 * 4) bytes space in the FIFO.

## 15.4.3 Looping Modes

The PSC can be configured to operate in various loopback modes as shown in Figure 15-90. These modes are useful for local and remote system diagnostic functions and can be used by in Codec mode as well as UART mode. The modes are described below and in Section 15.2.2, "Register Descriptions."

The PSCs transmitter and receiver should be disabled when switching between modes. The selected mode is activated immediately on mode selection, regardless of whether a character is being received or transmitted.

### 15.4.3.1 Automatic Echo Mode

In automatic echo mode, shown in Figure 15-90, the PSC automatically resends received data bit-by-bit. The local CPU-to-receiver communication continues normally, but the CPU-to-transmitter link is disabled. In this mode, received data is clocked on the receiver clock and resent on TxD. The receiver must be enabled, but the transmitter need not be.

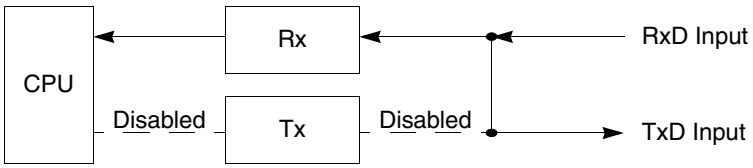



**Figure 15-90. Automatic Echo**

Because the transmitter is inactive, SR[TxEMP,TxRDY] is inactive and data is sent as it is received. Received parity is checked, but is not recalculated for transmission. Character framing is also checked, but stop bits are sent as they are received. A received break is echoed as received until the next valid start bit is detected.

### 15.4.3.2 Local Loop-Back Mode

Figure 15-91 shows how TxD and RxD are internally connected in local loop-back mode. This mode is for testing the operation of a local PSC module channel by sending data to the transmitter and checking data assembled by the receiver to ensure proper operations.

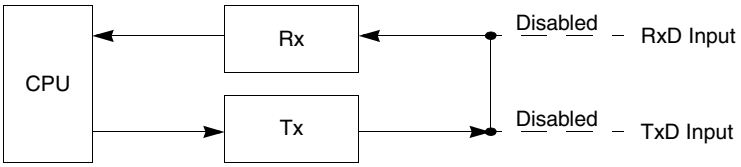



**Figure 15-91. Local Loop-Back**

Features of this local loop-back mode are:

- Transmitter and CPU-to-receiver communications continue normally.
- RxD input data is ignored.
- TxD data is held marking.
- The receiver is clocked by the transmitter clock.
- Transmitter must be enabled, but the receiver need not be enabled.

#### 15.4.3.3 Remote Loop-Back Mode

In remote loop-back mode, shown in Figure 15-92, the channel automatically transmits received data bit-by-bit on the TxD output. The local CPU-to-transmitter link is disabled. This mode is useful in testing receiver and transmitter operation of a remote channel. For this mode, the transmitter uses the receiver clock.

Because the receiver is not active, received data cannot be read by the CPU and error status conditions are inactive. Received parity is not checked and is not recalculated for transmission. Stop bits are sent as they are received. A received break is echoed as received until the next valid start bit is detected.

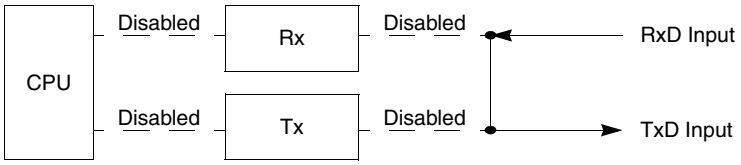



**Figure 15-92. Remote Loop-Back**

### 15.4.4 Multidrop Mode

Setting MR1[PM] programs the PSC to operate in a Walk-up mode for multidrop or multiprocessor applications. In this mode, a master can transmit an address character followed by a block of data characters targeted for one of up to 256 slave stations.

Although slave stations have their channel receivers disabled, they continuously monitor the masters data stream. When the master sends an address character, the slave receiver channel notifies its respective CPU by setting SR[RxRDY] and generating an interrupt (if programmed to do so). Each slave station CPU then compares the received address to its station address and enables its receiver if it wishes to receive the subsequent data characters or block of data from the master station. Slave stations not addressed continue monitoring the data stream. Data fields in the data stream are separated by an address character. After a slave receives a block of data, its CPU disables the receiver and repeats the process.

Figure 15-93 shows functional timing information for multidrop mode.

A character sent from the master station consists of:

- A start bit
- A programmed number of data bits
- An address/data (A/D) bit flag
  - A/D=1 indicates an address character
  - A/D=0 indicates a data character
- A programmed number of stop bits

A/D polarity is selected through MR1[PT]. MR1 should be programmed before enabling the transmitter and loading the corresponding data bits into the Tx buffer.

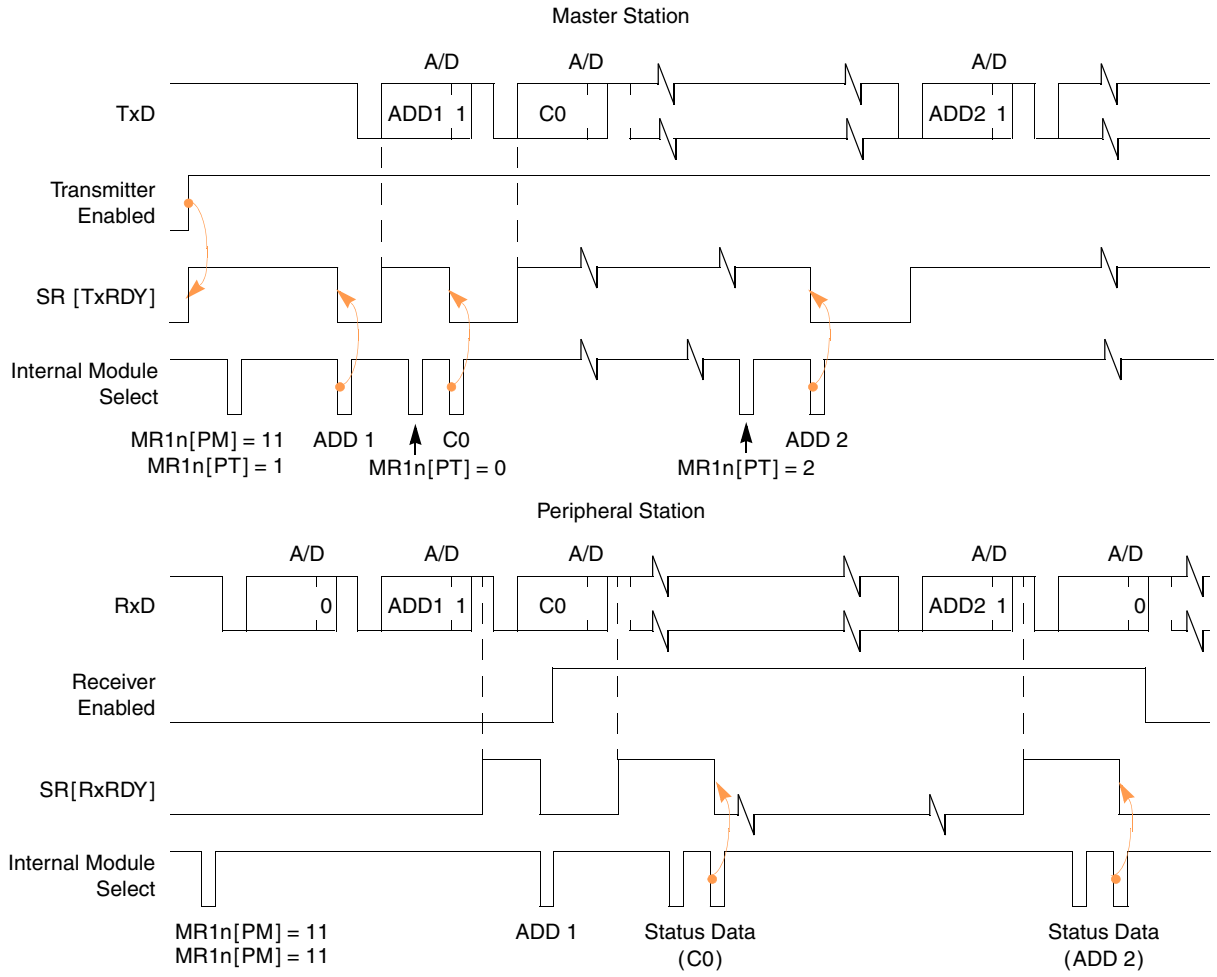



**Figure 15-93. Timing Diagram—Multidrop Mode**

In multidrop mode, the receiver continuously monitors the received data stream, regardless of whether it is enabled or disabled.

- If the receiver is disabled, it sets the RxRDY bit and loads the character into the receiver holding register FIFO stack, provided the received A/D bit is 1 (address tag). If the received A/D bit is 0 (data tag), the character is discarded.
- If the receiver is enabled, all received characters are transferred to the CPU through the receiver holding register stack during read operations.

In either case, data bits are loaded into the data portion of the stack while the A/D bit is loaded into the status portion of the stack normally used for a parity error (SR[PE]).

Framing error, overrun error, and break detection operate normally. The A/D bit takes the place of the parity bit. Parity is neither calculated nor checked. Messages in this mode may still contain error detection and correction information. One way to provide error detection if 8-bit characters are not required, is to use software to calculate parity and append it to the 5-, 6-, or 7-bit character.

# Chapter 16
# XLB Arbiter

## 16.1 Overview

This document contains the following sections:

- Section 16.1, “Overview
- Section 16.2.1, “XLB Arbiter Registers

### 16.1.1 Purpose

The purpose of the XLB Arbiter is to manage bus requests from the XLB masters (USB, PCI, BestComm, and e300 core), and determine which master should be granted the bus at any one time. The arbiter employs both master prioritization and a fair-share LRU (least-recently-used) algorithm to reduce access latency and starvation across all masters.

The XLB Arbiter consists of five functional blocks as shown below.

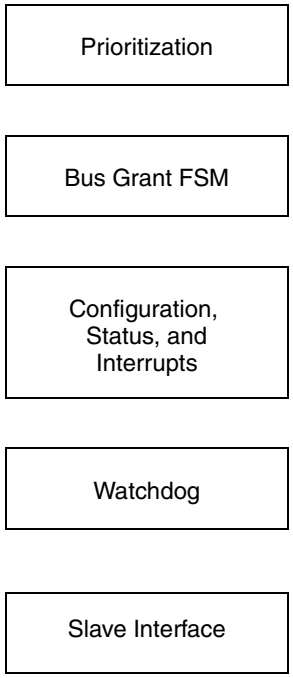



**Figure 16-1. Block Diagram of XLB Arbiter**

#### 16.1.1.1 Prioritization

The prioritization block signals that a master is requesting the bus and which master has priority.

Priority is determined first by using the master priority level assigned by either the hardware-wired internal signals, or software-programmable Master N Priority bits in the Arbiter Master N Priority Register depending on the Master Priority Enable bit for each master. Masters at the same level of priority will be further sorted by a least recently used algorithm (LRU). Once a requesting master is identified as having priority and is granted the bus, that master will be continue to be granted the bus if:

1. It is requesting the bus. The request must occur immediately after the required one clock de-assertion after a qualified bus grant, and
2. It is the highest priority device, and
3. There is no address retry assertion.

Multiple masters at level 0 will only be able to perform one tenure before the bus is passed to the next master at level 0 using the LRU algorithm.

The priority level of each master may be changed while the arbiter is running. This allows dynamic changes in priority such as an aging scheme. It is possible for the e300 core to control priority by enabling the Master Priority Enable bits for a master. This causes the priority to be determined from the Master N Priority bits in the Arbiter Master N Priority Register. The e300 core then may write this register to set the master's priority.

#### 16.1.1.2 Bus Grant Mechanism

##### 16.1.1.2.1 Bus Grant

The Bus Grant mechanism will generate the address bus grant signals to the masters using the signals from the prioritization function as well as the internal XL bus signals (ts_b, aack_b, ta_b, tt[0:4], artry, tbst_b, tea_b, dbb_b). It will also generate required indicators of state to the prioritization and watchdog functions.

The Bus Grant mechanism will enforce a one level address pipeline, if pipelining is enabled (via the PLDIS bit in the Arbiter Configuration Register). The critical condition is that before a third address tenure is granted, the first tenure (address, and if needed, data) must be completed. The arbiter will assert bus grant to a master when the master is requesting, or if parking is enabled, and the one level pipeline condition is met.

##### 16.1.1.2.2 Parking Modes

The Bus Grant mechanism will support the No Parking, Park on Programmed Master, and Park on Last Master bus parking modes. When in No Parking Mode, the arbiter will not assert bus grant when there are no masters asserting bus request. In Park on Programmed Master Mode, the arbiter will assert bus grant to the master indicated in the Select Parked Master bits (Arbiter Configuration Register, SP[2:0] bits) when no masters are asserting bus request, and the one level pipeline will not be violated. In Park on Last Master Mode, the arbiter will assert bus grant to the last master granted the bus when no masters are asserting bus request, and the one level pipeline will not be violated.

#### 16.1.1.3 Configuration, Status, and Interrupt Generation

This block provides a set of status and configuration registers as well as interrupt generation for enabled interrupt conditions. These registers are detailed in the register section below. Some registers have reserved (unused, undefined) bits. These bits will always read as 0, and if written, should be written to 0 for future software compatibility.

#### 16.1.1.4 Watchdog Functions

##### 16.1.1.4.1 Timer Functions

There are three watchdog timers for address tenure, data tenure, and bus activity time out. Each has a programmable timer count and can be disabled. A timer time-out will set a status bit and trigger an interrupt if that interrupt is enabled.

The address tenure watchdog is a 32-bit timer. If an AACK is not detected by the programmed number of clocks after bus grant is accepted, the address watchdog timer will expire and the arbiter will issue AACK. The related data tenure will be terminated with TEA. The arbiter will set the Address Tenure Time-out Status bit in the Arbiter Status Register and issue an interrupt if that interrupt is enabled.

The upper 28-bits of address tenure time-out are programmed via the Address Tenure Time-out Register. The lower 4 bits are always 0xF.

The data tenure watchdog is a 32-bit timer. If a data tenure is not terminated, the data watchdog timer will expire and the arbiter will issue TEA. The arbiter will set the Data Tenure Time-out Status bit in the Arbiter Status Register and issue an interrupt if that interrupt is enabled.

Address Time-out (32 bits) = {Address Tenure Time-out Register (28-bits), 0xF}

Data Time-out (32 bits) = {Data Tenure Time-out Register (28-bits), 0xF}

**NOTE**

Enabling the data time-out will also enable the address time-out. This is required to prevent a data time-out before an AACK assertion.

The bus activity watchdog is a 32-bit timer. If no bus activity (no assertion of DBB or ABB) is detected by the programmed number of clocks, the bus activity watchdog timer will expire and the arbiter will set the Bus Activity Time-out Status bit in the Arbiter Status Register and issue an interrupt if that interrupt is enabled.

For any TEA assertion (from a watchdog time-out, or other source), a Machine Check exception will result in the e300 core. See the XLB Arbiter interrupt enablement recommendations below for the Arbiter Interrupt Enable Register. For more information on the Machine Check exception, see the 603e Users' Manual, Section 4.5.

#### 16.1.1.4.2 Other Tenure Ending Conditions

In addition to the watchdog timers, this function will terminate tenures with or without TEA depending on the following conditions:

- AACK the address tenure for **eciwx** and **ecowx** transfer types, then TEA the ensuing data tenure. This sets the External Control Word Read/Write Status bit in the Arbiter Status Register.
- AACK the address tenure for address only and reserved transfer types. (no ensuing data tenure) This sets the TT Address Only Status bit or TT Reserved Status Bit, respectively, in the Arbiter Status Register.
- AACK the address tenure for invalid TBST/TSIZ combinations, then TEA the ensuing data tenure. This sets the TBST/TSIZ Mismatch Status bit in the Arbiter Status Register.

If enabled, an interrupt will be issued when a status bit is set.

When the arbiter ends a tenure or detects a TEA from a device, certain bus signals (Address, TT, TSIZ, TBST, GLB) are latched into the Arbiter Address Capture Register and Arbiter Bus Signal Capture Register. Additional errors will be handled but the original error related information is maintained until the error status is cleared.

## 16.2 Register Descriptions

### 16.2.1 XLB Arbiter Registers

The XLB Arbiter provides thirteen 32-bit active registers. All registers are located at an offset from the Module Base Address Register (MBAR). The XLB Arbiter offset from MBAR is 0x1F00. Therefore, the actual address for each XLB Arbiter register is: **MBAR + 0x1F00 + register address.**

The read/write nature of each register is shown in the descriptions that follow.

- Bit 0 in all registers is the most significant bit (MSB).
- Reserved bits cannot be written to, and will always read 0.
- Registers may be accessed on the following aligned boundaries:
  - 1 byte
  - 2 byte
  - word (32-bit)
  - double-word (64-bit)

Registers are organized on word boundaries to allow easy register mask operations.

When a bit enables or disables a function, the values are defined as:

- 0 = disabled
- 1 = enabled

The XLB Arbiter registers are listed below, followed by detailed descriptions of each register.

- Arbiter Configuration Register (R/W)
- Arbiter Address Tenure Time-Out Register (R/W)
- Arbiter Version Register (R)
- Arbiter Data Tenure Time-Out Register (R/W)
- Arbiter Status Register (R/W)
- Arbiter Bus Activity Time-Out Register (R/W)
- Arbiter Interrupt Enable Register (R/W)
- Arbiter Master Priority Enable Register (R/W)
- Arbiter Address Capture Register (R)
- Arbiter Master Priority Register (R/W)
- Arbiter Bus Signal Capture Register (R)
- Arbiter Snoop Window Register (RW)

### 16.2.1.1 Arbiter Configuration Register (R/W)

The Arbiter Configuration Register is used to control the arbiter watchdog functionality and other XLB-related system configuration parameters.

Address MBAR + 0x1F40

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | PLDIS | Reserved | | | | | | | | | | | | | | BSDIS |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | SE | USE_WWF | TBEN | Rsvd | WS | SP | | | Rsvd | PM | | Rsvd | BA | DT | AT | Rsvd |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |

**Figure 16-2. Arbiter Configuration Register**

**Table 16-1. Arbiter Configuration Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | PLDIS | Pipeline Disable. This bit is used to enable or disable transaction pipelining on the XLB. See note below.<br>0 Enable pipelining<br>1 Disable pipelining |
| 1:14 | — | Reserved |
| 15 | BSDIS | BestComm Snooping Disable.<br>0 BestComm XLB address snooping enabled.<br>1 BestComm XLB address snooping disabled. |

**Table 16-1. Arbiter Configuration Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 16 | SE | Snoop Enable. This sets the address snooping enablement on the XLB.<br>0 Disable address snooping. Internally on the XLB, the gbl_b signal is gated (always negated). This overrides any setting of the Arbiter Snoop Window Register (RW).<br>1 Allow address snooping. Internally on the XLB, the gbl_b signal is not gated, and assertions of this signal during address tenures will be recognized. |
| 17 | USE_WWF | Force write-with-flush transfer type (TT) for PCI, BestComm, and USB interfaces to XLB.<br>0 Write-with-kill operation is allowed on burst transactions.<br>1 Always use write-with-flush on burst transactions. |
| 18 | TBEN | Timebase Enable. This bit is used as a “count enable” control input for the timebase counter in the 603e core.<br>0 Timebase should stop clocking.<br>1 Timebase should continue clocking. |
| 19 | — | Reserved |
| 20 | WS | Minimum Wait State. This bit sets the minimum number of wait states for slaves to respond with AACK assertion on the XLB.<br>0 0 minimum wait state.<br>1 1 minimum wait state. |
| 21:23 | SP[2:0] | Select Parked Master. These bits set the master that is used in Park on Programmed Master mode (000 = master 0, 001 = master 1, ..., 111 = master 7). |
| 24 | — | Reserved |
| 25:26 | PM[1:0] | Parking Mode.<br>00 No parking (default).<br>01 Reserved.<br>10 Park on most recently used master.<br>11 Park on programmed master as specified by the Select Parked Master bits 21:23 above. |
| 27 | — | Reserved |
| 28 | BA | Bus Activity Time-out Enable. If enabled, the arbiter will set the Bus Activity Time-out Status bit (Arbiter Status Register, bit 29) when the Bus Activity Time-out is reached. Bus Activity Time-out is derived from the Arbiter Bus Activity Time Out Count register. |
| 29 | DT | Data Tenure Time-out Enable. If enabled, the arbiter will assert TEA when the Data Tenure Time-out is reached. Data Tenure Time-out is derived from the Arbiter Data Tenure Time Out Count Register. Also, the arbiter will set the Data Tenure Time-out Status bit (Arbiter Status Register, bit 30). Setting this bit will also enable the Address Tenure Time-out. This is required to ensure that a data time-out will not occur before an address acknowledge. |
| 30 | AT | Address Tenure Time-out Enable. If enabled, the arbiter will assert AACK and TEA (if required) when the Address Tenure Time-out is reached. Address Tenure Time-out is derived from the Arbiter Address Tenure Time Out Count register. Also, the arbiter will set the Address Tenure Time-out Status bit (Arbiter Status Register, bit 31). Address Tenure Time-out is also enabled by the DT bit above. |
| 31 | — | Reserved |

## NOTE

The PLDIS reset value is 1, which means the XLB Arbiter will prohibit transaction pipelining. In most applications, transaction pipelining will provide a significant performance increase, and therefore the customer should consider setting this bit to 0 to take advantage of this increase.

### 16.2.1.2 Arbiter Version Register (R)

The Arbiter Version Register contains the silicon version number for the arbiter hardware.

Address MBAR + 0x1F44

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Version ID[0:15] | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Version ID[16:31] | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Figure 16-3. Arbiter Version Register**

**Table 16-2. Arbiter Version Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:31 | VER | Hardware version ID. The current version number is 0x0001. |

### 16.2.1.3 Arbiter Status Register (R/W)

The Arbiter Status Register indicates the state of watchdog functions. When a monitored condition occurs, the respective bit is set to 1. The bit remains 1 until cleared by writing 1 into that bit position. Even if the causal condition is removed, the bit remains set until cleared.

Address MBAR + 0x1F48

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | SEA | MM | TTA | TTR | ECW | TTM | BA | DT | AT |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 16-4. Arbiter Status Register**

**Table 16-3. Arbiter Status Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:22 | — | Reserved |
| 23 | SEA | Slave Error Acknowledge. This bit is set when an error is detected by any slave devices during the transfer. |
| 24 | MM | Multiple Masters at Priority 0. If more than one master is recognized at priority 0, this bit is set. Once this occurs, this bit will remain set until cleared. The arbiter recognizes priority by the hardware-wired mNpri signals or (if enabled) the Arbiter Master N Priority Register. This bit is intended to help in tuning dynamic priority algorithm development. |
| 25 | TTA | TT Address Only. The arbiter automatically AACKs for address only TT (transfer type) codes. This bit is set when this condition occurs.<br>For a description of TT codes, see the MPC603e Users' Manual, Section 7.2. |
| 26 | TTR | TT Reserved. The arbiter automatically AACKs for reserved TT (transfer type) codes. This bit is set when this condition occurs.<br>For a description of TT codes, see the MPC603e Users' Manual, Section 7.2. |
| 27 | ECW | External Control Word Read/Write. External Control Word Read/Write operations are not supported on the XLB. If either occur, the arbiter AACKs and TEAs the transaction, and sets this bit. |
| 28 | TTM | TBST/TSIZ mismatch. Set when an illegal/reserved TBST and TSIZ[0:2] combinations occur. These combinations are TBST asserted and TSIZ[0:2] = 000, 001, 011, or 1xx (where "x" is 0 or 1).<br>For a description of TBST and TSIZ, see the MPC603e Users' Manual, Section 7.2. |
| 29 | BA | Bus Activity Tenure Time-out. Set when the bus activity time-out counter expires. |
| 30 | DT | Data Tenure Time-out. Set when the data tenure time-out counter expires. |
| 31 | AT | Address Tenure Time-out. Set when the address tenure time-out counter expires. |

### 16.2.1.4 Arbiter Interrupt Enable Register (R/W)

The Arbiter Interrupt Enable Register is used to enable a status bit to cause an interrupt. If the interrupt enable and corresponding status bits are set in the Arbiter Status Register and the Arbiter Interrupt Enable Register, the arbiter will assert the internal arb_int signal. Normally, an interrupt service routine would read the status register to determine the state of the arbiter. It is possible that multiple conditions exist that would cause an interrupt. Disabling an interrupt by writing a 0 to a bit in this register will not clear the status bit in the Arbiter Status Register.

**NOTE**

For SEAE, ECWE, TTME and ATE interrupt conditions, the arbiter also generates a TEA at a later time (dependent upon XL bus activity), which will cause a Machine Check exception. As a result, state information for the interrupted exception in the save/restore registers (SRR0 and SRR1) may be lost. Therefore, it is recommended that SEA, ECW, TTM, and ATE remain disabled at all times. It is possible to enable an arbiter interrupt for MME, TTAE, TTRE, as they do not result in a TEA; in case of DTE and BAE, arbiter interrupt can be enabled, as the TEA assertion always precedes the interrupt.

Address MBAR + 0x1F4C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | SEAE | MME | TTAE | TTRE | ECWE | TTME | BAE | DTE | ATE |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 16-5. Arbiter Interrupt Enable Register**

**Table 16-4. Arbiter Interrupt Enable Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:22 | — | Reserved |
| 23 | SEAE | Slave Error Acknowledge interrupt enable |
| 24 | MME | Multiple Masters at priority 0 interrupt enable |
| 25 | TTAE | TT Address Only interrupt enable |
| 26 | TTRE | TT Reserved interrupt enable |
| 27 | ECWE | External Control Word Read/Write interrupt enable |
| 28 | TTME | TBST/TSIZ mismatch interrupt enable |
| 29 | BAE | Bus Activity Tenure Time-out interrupt enable |

**Table 16-4. Arbiter Interrupt Enable Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 30 | DTE | Data Tenure Time-out interrupt enable |
| 31 | ATE | Address Tenure Time-out interrupt enable |

### 16.2.1.5 Arbiter Address Capture Register (R)

The Arbiter Address Capture Register captures the address for a tenure that has either:

- An address time-out,
- A data time-out, or
- A TEA from another source

The captured value is held until unlocked by writing any value to the Arbiter Address Capture Register or Arbiter Bus Signal Capture Register. This value is also unlocked by writing a 1 to either the Arbiter Status Register, bit 30 (Data Tenure Time-out Status) or bit 31 (Address Tenure Time-Out Status). Unlocking the register does not clear its contents.

Address MBAR + 0x1F50

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Address[0:15] | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Address[16:31] | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 16-6. Arbiter Address Capture Register**

**Table 16-5. Arbiter Address Capture Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:31 | ADRCAP | Address Capture Value. This is the address that is captured when a bus error occurs. This happens after an address time-out, data time-out, or any TEA assertion. |

### 16.2.1.6 Arbiter Bus Signal Capture Register (R)

The Arbiter Bus Signal Capture Register captures TT, TBST, GBL, and TSIZ for an XLB address tenure that has either:

- An address time-out,
- A data time-out, or
- A TEA from another source

These values are held until unlocked by writing any value to the Arbiter Address Capture Register or Arbiter Bus Signal Capture Register. These values are also unlocked by writing 1 to either the Arbiter Status Register, bit 30 (Data Tenure Time-out Status) or bit 31 (Address Tenure Time-Out Status). Unlocking the register does not clear its contents.

Address MBAR + 0x1F54

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | TSIZ[0:2] | | | GBL | TBST | TT[0:4] | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 16-7. Arbiter Bus Signal Capture Register**

**Table 16-6. Arbiter Bus Signal Capture Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:21 | — | Reserved |
| 22:24 | TSIZ | Captured Value of TSIZ[0:2]. |
| 25 | GBL | Captured Value of GBL. |
| 26 | TBST | Captured Value of TBST. |
| 27:31 | TT | Captured Value of TT[0:4]. |

### 16.2.1.7 Arbiter Address Tenure Time-Out Register (R/W)

The Arbiter Address Tenure Time-out Register provides an expiration value to the arbiter watchdog for address tenures. After an address tenure is initiated with a TS signal assertion by the master, the address tenure watchdog starts counting until either AACK is asserted, or the counter expires. If expiration occurs before the AACK is encountered, the arbiter issues an AACK assertion, followed by a TEA assertion for the corresponding data tenure. Subsequently, the Arbiter Status Register, bit 31 (AT) is set, and an interrupt is generated if the Arbiter Interrupt Enable Register, bit 31 (ATE) is set.

The Arbiter Address Tenure watchdog can be enabled/disabled via the Arbiter Configuration Register, bit 30 (AT).

Address MBAR + 0x1F58

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | ADRTO[4:15] | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | ADRTO[16:31] | | | | | | | | | | | | | | | |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Figure 16-8. Arbiter Address Tenure Time-Out Register**

**Table 16-7. Arbiter Address Tenure Time-Out Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:31 | ADRTO | Address Tenure Time-out. Contains the upper 28 bits of the Address Time-out Counter. Values represent increments of 16. Default value is 0xFFFFFFF. |

### 16.2.1.8 Arbiter Data Tenure Time-Out Register (R/W)

The Arbiter Data Tenure Time-out Register provides an expiration value to the arbiter watchdog for data tenures. After a data tenure is initiated with a DBB signal assertion by the master, the data tenure watchdog starts counting until either TA is asserted, or the counter expires. If expiration occurs before TA is encountered, the arbiter issues a TEA assertion for the data tenure. Subsequently, the Arbiter Status Register, bit 30 (DT) is set, and an interrupt is generated if the Arbiter Interrupt Enable Register, bit 30 (DTE) is set.

The Arbiter Data Tenure watchdog can be enabled/disabled via the Arbiter Configuration Register, bit 29 (AT).

Address MBAR + 0x1F5C

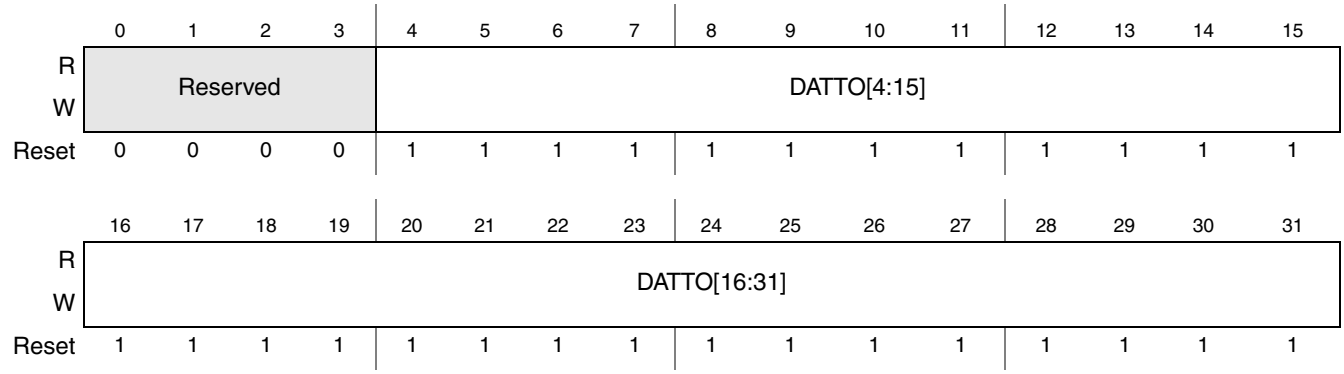



**Figure 16-9. Arbiter Data Tenure Time-Out Register**

**Table 16-8. Arbiter Data Tenure Time-Out Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:31 | DATTO | Data Tenure Time-out. Contains the upper 28 bits of the DataTime-out Counter. Values represent increments of 16. Default value is 0xFFFFFFF. |

### 16.2.1.9 Arbiter Bus Activity Time-Out Register (R/W)

The Arbiter Bus Activity Time-out Register provides an expiration value to the arbiter watchdog for bus activity. The watchdog monitors bus activity, after the counter expires due to excessive bus idle time, the Arbiter Status Register, bit 29 (BA) is set, and an interrupt is generated if the Arbiter Interrupt Enable Register, bit 29 (BAE) is set.

The Arbiter Bus Activity watchdog can be enabled/disabled via the Arbiter Configuration Register, bit 28 (BA).

Address MBAR + 0x1F60

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | BUSTO[0:15] | | | | | | | | | | | | | | | |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | BUSTO[16:31] | | | | | | | | | | | | | | | |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Figure 16-10. Arbiter Bus Activity Time-Out Register**

**Table 16-9. Arbiter Bus Activity Time-Out Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:31 | BUSTO | Bus Activity Time-out. Contains the value of the Bus Activity Time-out Counter. Values represent increments of 1. Default value is 0xFFFFFFFF. |

### 16.2.1.10 Arbiter Master Priority Enable Register (R/W)

The Arbiter Master Priority Enable Register determines whether the arbiter uses the hard-wired or software programmable priority for a master. The default is enabled for all masters. Both methods may be employed at the same time for different masters. This register may be written to at any time, and the change becomes effective one clock after the register is written.

When enabled, the software programmable value in the Arbiter Master N Priority Register is used as the priority for the master. When disabled, the priority assignment for each master is determined by the hardware-wired mNpri signals, as shown in Table 16-11.

Address MBAR + 0x1F64

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | M7 | M6 | M5 | M4 | M3 | M2 | M1 | M0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Figure 16-11. Arbiter Master Priority Enable Register**

**Table 16-10. Arbiter Master Priority Enable Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:23 | — | Reserved |
| 24 | M7 | Master 7 Priority Register Enable |
| 25 | M6 | Master 6 Priority Register Enable |
| 26 | M5 | Master 5 Priority Register Enable |
| 27 | M4 | Master 4 Priority Register Enable |
| 28 | M3 | Master 3 Priority Register Enable |
| 29 | M2 | Master 2 Priority Register Enable |
| 30 | M1 | Master 1 Priority Register Enable |
| 40 | M0 | Master 0 Priority Register Enable |

**Table 16-11. Hardware Assignments of Master Priority**

| Master | Priority | Description |
|---|---|---|
| M7–M4 | — | Unused |
| M3 | 0 | PCI Target Interface |
| M2 | 1 | BestComm |
| M1 | 2 | USB |
| M0 | 7 | e300 Core |

### 16.2.1.11 Arbiter Master Priority Register (R/W)

The Arbiter Master N Priority Register is used to set the software-programmable priority of each master. This register is used in conjunction with the Arbiter Master Priority Enable Register to enable software-programmable master priorities, consequently ignoring internal, hardware-wired signals. This register may be written at any time, and changes to this register become effective one clock after the register is written.

Valid priority values range from 0 to 7, with 0 being the highest priority. Each of the eight fields in the register has the upper (fourth) bit reserved. This allows for a possible future expansion to 16 priority levels. Currently, the reserved bits will always read as 0, and should be written as 0 for future software compatibility.

Address MBAR + 0x1F68

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Rsvd | M7 Priority | | | Rsvd | M6 Priority | | | Rsvd | M5 Priority | | | Rsvd | M4 Priority | | |
| Reset | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Rsvd | M3 Priority | | | Rsvd | M2 Priority | | | Rsvd | M1 Priority | | | Rsvd | M0 Priority | | |
| Reset | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |

**Figure 16-12. Arbiter Master Priority Register**

**Table 16-12. Arbiter Master Priority Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | — | Reserved |
| 1:3 | M7P | Master 7 Priority |
| 4 | — | Reserved |
| 5:7 | M6P | Master 6 Priority |
| 8 | — | Reserved |
| 9:11 | M5P | Master 5 Priority |
| 12 | — | Reserved |
| 13:15 | M4P | Master 4 Priority |
| 16 | — | Reserved |
| 17:19 | M3P | Master 3 Priority |
| 20 | — | Reserved |
| 21:23 | M2P | Master 2 Priority |
| 24 | — | Reserved |
| 25:27 | M1P | Master 1 Priority |
| 28 | — | Reserved |
| 29:31 | M0P | Master 0 Priority |

### 16.2.1.12 Arbiter Snoop Window Register (RW)

The Arbiter Snoop Window Register is used by the PCI, BestComm, and USB Host interfaces to the XLB. This register dictates the size of an address range in memory that will allow or prohibit address snooping. Each master interface (MBI) monitors this register and determines if the master's address transferred to the XLB should be sent with gbl_b signal assertion.

The benefit of this implementation of a system-wide address snooping control mechanism is that address ranges that need not be cache-coherent will not be snooped by the core. Under certain conditions, the core can assert an internal signal, ARTRY, when it is too busy to check the cache for a snooped address on the bus. Therefore, by specifying an address range that doesn't require snooping, the number of core-initiated "busy ARTRY" scenarios can be minimized, and the subsequent time penalty to eventually retry the transaction is avoided. The quantity of this incremental system performance increase is dependant upon the loading of core (especially as related to the caches), and the average number of accesses to the designated regions of the snoop window.

The MPC5200B implementation of this address snooping control is shown in the figure below. At the start of a master's address tenure, the master interface decodes the address and determines if it needs to be snooped, based on the configuration of the Arbiter Snoop Window Register. If the transaction requires snooping, the gbl_b signal is asserted; otherwise, gbl_b is negated. However, before the gbl_b signal reaches the XLB for the address tenure, it is gated by a mux, controlled by the Arbiter Configuration Register SE (snoop enable) bit. If SE is 0, gbl_b will always be negated, and no XLB transaction will be snooped. If SE is 1, the gbl_b signal generated by the master bus interface will be allowed to pass to the XLB.

For a more detailed description of address snooping and e300 cache-coherency, see the MCP603e Users' Manual, Section 3.6.

Address MBAR + 0x1F70

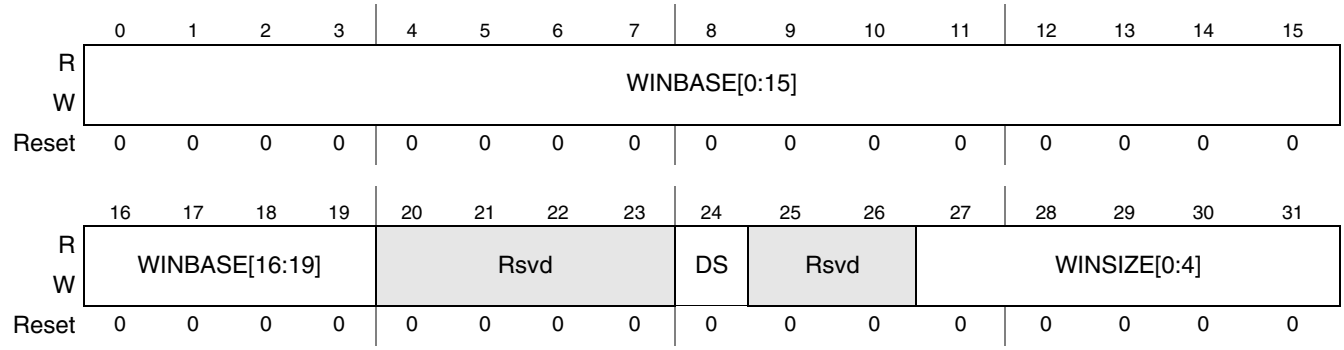



**Figure 16-13. Arbiter Snoop Window Register**

**Table 16-13. Arbiter Snoop Window Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:19 | WINBASE | Window Base Address. Defines the base address of snoopable/non-snoopable addresses for all PCI, BestComm, and USB address transfers. |
| 20:23 | — | Reserved |

**Table 16-13. Arbiter Snoop Window Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 24 | DS | Default Snooping Policy:<br>0 Addresses inside window are snooped. Default gbl_b = “negated”<br>1 Addresses outside window are snooped. Default gbl_b = “asserted” |
| 25:26 | — | Reserved |
| 27:31 | WINSIZE | Window Size -— Defines the size of window. The lower bits of WINBASE are effectively ignored/masked from snooping address comparison depending on the value set in this field.<br>WINSIZE = 00000: Window miss*<br>WINSIZE = 00001 - 01011: 4KByte (non-mask)<br>WINSIZE = 01100: 8KByte (1 bit mask)<br>WINSIZE = 01101: 16KByte (2 bits mask)<br>WINSIZE = 01110: 32KByte (3 bits mask)<br>WINSIZE = 01111: 64KByte (4 bits mask)<br>WINSIZE = 10000: 128KByte (5 bits mask)<br>WINSIZE = 10001: 256KByte (6 bits mask)<br>WINSIZE = 10010: 512KByte (7 bits mask)<br>WINSIZE = 10011: 1MByte (8 bits mask)<br>WINSIZE = 10100: 2MByte (9 bits mask)<br>WINSIZE = 10101: 4MByte (10 bits mask)<br>WINSIZE = 10110: 8MByte (11 bits mask)<br>WINSIZE = 10111: 16MByte (12 bits mask)<br>WINSIZE = 11000: 32MByte (13 bits mask)<br>WINSIZE = 11001: 64MByte (14 bits mask)<br>WINSIZE = 11010: 128MByte (15 bits mask)<br>WINSIZE = 11011: 256MByte (16 bits mask)<br>WINSIZE = 11100: 512MByte (17 bits mask)<br>WINSIZE = 11101: 1GByte (18 bits mask)<br>WINSIZE = : 2GByte (19 bits mask)<br>WINSIZE = 11111: Reserved<br>**Note:** Software should always write a non-zero value in this field. Otherwise, the address comparison does not take effect (treated as a “window miss”). |

## 16.2.2 Arbiter Reserved Registers

These are reserved registers and should not be accessed.

Address MBAR + 0x1F00–0x1F3C, 0x174–0x1FFF

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 16-14. Arbiter Reserved Registers**

**Table 16-14. Arbiter Reserved Registers Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:31 | — | Reserved |

# Chapter 17
# Serial Peripheral Interface (SPI)

## 17.1 Overview

The following sections are contained in this document:

- Section 17.2, “SPI Signal Description”
- Section 17.3, “Memory Map and Register Definitions”
- Section 17.4, “Functional Description”

The Serial Peripheral Interface (SPI) allows full-duplex, synchronous, serial communication between the MPC5200B and peripheral devices. Software can poll the SPI status flags or the SPI operation can be interrupt driven.

Figure 17-1 shows the SPI block diagram.

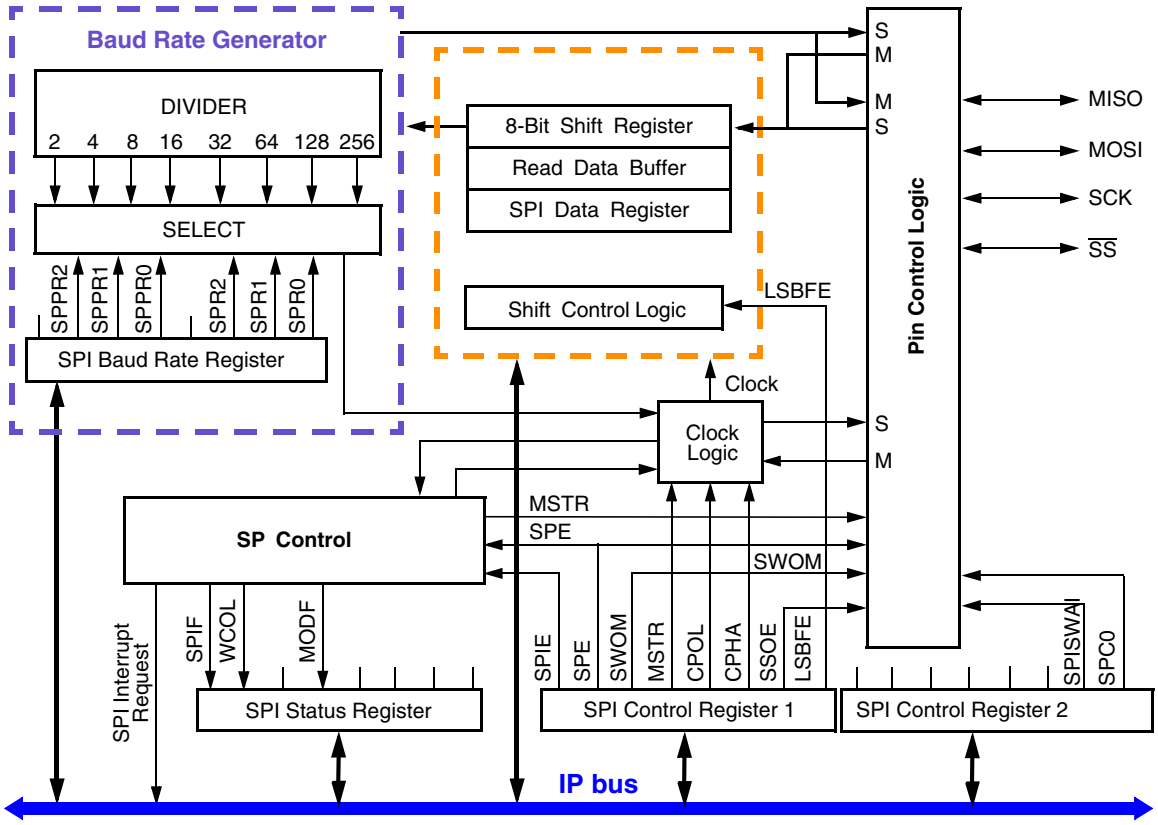



**Figure 17-1. Block Diagram—SPI**

### 17.1.1 Features

The SPI has the following features:

- Master mode and slave mode
- Bi-directional mode
- Slave-select output
- Mode fault error flag with CPU interrupt capability
- Double-buffered data register
- Serial clock with programmable polarity and phase
- Control of SPI operation during wait mode

### 17.1.2 Modes of Operation

The SPI functions in the following three modes:

- **Run Mode**—The normal mode of operation.
- **Wait Mode**—The SPI can be configured to operate in low-power mode. Based on the internal bit state, the SPI can operate normally when the CPU is in wait mode or the SPI clock generation can be turned off and the SPI module enters a power conservation state during wait mode. During wait mode, any master transmission in progress stops. Transmission and reception resumes when the SPI exits wait mode.
- **Stop Mode**—This mode is system dependent. The SPI enters the stop mode when the module clock is disabled (held high or low). If the SPI is in master mode and exchanging data when the processor enters stop mode, the transmission stops until the processor exits stop mode.

## 17.2 SPI Signal Description

Table 17-1 shows external SPI signals and their properties. These signals may connect off-chip. Detailed signal descriptions are given in the sections below.

**Table 17-1. SPI External Signal Descriptions**

| Signal Name | Port | Function[1] | Reset State |
|---|---|---|---|
| MISO | SPIPORT[7] | Master Data In/Slave Data Out | 0 |
| MOSI | SPIPORT[6] | Master Data Out/Slave Data In | 0 |
| SCK | SPIPORT[5] | Serial Clock | 0 |
| $\overline{SS}$ | SPIPORT[4] | Slave Select | 0 |

[1] SPI ports MISO, MOSI, SCK, and $\overline{SS}$ are GPIO ports when SPI is disabled (SPE=0).

### 17.2.1 Master In/Slave Out (MISO)

MISO is one of two SPI module pins that transmit serial data. MISO is an input when the SPI is configured as a master and an output when the SPI is configured as a slave.

If the bidirectional serial pin mode is selected as a slave, MISO becomes a slave in/slave out (SISO) and the direction is controlled by the associated bit in the SPI port data direction register.

In a multiple-master system, all MISO pins are tied together.

### 17.2.2 Master Out/Slave In (MOSI)

MOSI is one of two SPI module pins that transmit serial data. MOSI is an output when the SPI is configured as a master and an input when the SPI is configured as a slave.

If the bidirectional serial pin mode is selected as a master, MOSI becomes master out/master in (MOMI) and the direction is controlled by the associated bit in the SPI port data direction register.

In a multiple-master system, all MOSI pins are tied together.

### 17.2.3 Serial Clock (SCK)

The serial clock synchronizes data transmissions between master and slave devices. SCK is an output if the SPI is configured as a master and SCK is an input if the SPI is configured as a slave.

In master mode the Serial Clock is derived from the IPB clock.

In a multiple-master system, all SCK pins are tied together.

### 17.2.4 Slave-Select ($\overline{SS}$)

The slave-select output or input provides a means of selectively enabling slaves so several may coexist in one system. $\overline{SS}$ is either a general-purpose output (SSOE = 0) or the slave select output (SSOE = 1) when the SPI is in master mode and the associated data direction bit is set.

The $\overline{SS}$ pin is the mode fault input when the SPI is in master mode and the associated data direction bit is clear. When the data direction bit is clear and SSOE = 1, the $\overline{SS}$ pin is a general-purpose input.

$\overline{SS}$ is always an input when the SPI is in slave mode, regardless of the state of the data direction bit for that pin. When the SPI is configured as a slave, the MISO (or SISO) output driver is three-stated until enabled by the slave select input (low true) so that many slaves may be wire-ORed to the same MISO (or SISO) line.

The directions of the MOSI and MISO pins are also determined by the serial pin control (SPC[0]) bit.

## 17.3 Memory Map and Register Definitions

This section gives a detailed description of memory and accessible registers.

These registers are located at an offset from MBAR of 0x0F00. Register addresses are relative to this offset. Therefore, the actual register address is: **MBAR + 0x0F00 + register address**

Reads from a non-implemented address returns zeros, writes to a non-implemented address has no effect.

### 17.3.1 Register Descriptions

Hyperlinks to the SPI registers are provided below:

- SPI Control Register 1 (0x0F00)
- SPI Control Register 2 (0x0F01)
- SPI Baud Rate Register (0x0F04)
- SPI Status Register (0x0F05)
- SPI Data Register (0x0F09)
- SPI Port Data Register (0x0F0D)
- SPI Data Direction Register (0x0F10)

### 17.3.1.1 SPI Control Register 1

Address MBAR + 0x0F00

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | SPIE | SPE | SWOM<br>(unused) | MSTR | CPOL | CPHA | SSOE | LSBFE |
| Reset | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

**Figure 17-2. SPI Control Register 1**

**Table 17-2. SPI Control Register 1 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | SPIE | SPI Interrupt Enable—bit enables SPI interrupts each time the SPIF or MODF status flag is set.<br>0 SPI interrupts disabled<br>1 SPI interrupts enabled |
| 1 | SPE | SPI System Enable—bit enables the SPI system and dedicates SPI port pins 3–0 to SPI functions. When SPE is clear, the SPI system is initialized, but in a low-power disabled state.<br>0 SPI system is in a low-power, disabled state<br>1 SPI port pins 3–0 are dedicated to SPI functions |
| 2 | SWOM | Unused |
| 3 | MSTR | SPI Master/Slave Mode Select bit<br>0 Slave mode<br>1 Master mode |
| 4 | CPOL | SPI Clock Polarity—bit selects an inverted or non-inverted SPI clock. To transmit data between SPI modules, the SPI modules must have identical CPOL values<br>0 Active-high clocks selected; SCK idles low<br>1 Active-low clocks selected; SCK idles high |
| 5 | CPHA | SPI Clock Phase—bit is used to shift the SCK serial clock.<br>0 The first SCK edge is issued one-half cycle into the 8-cycle transfer operation<br>1 The first SCK edge is issued at the beginning of the 8-cycle transfer operation |
| 6 | SSOE | Slave Select ($\overline{SS}$) Output Enable—bit is enabled only in master mode by asserting SSOE and SPIDDR bit 3 as shown in Table 17-3. |
| 7 | LSBFE | SPI LSB-First Enable—bit does not affect the position of the msb and lsb in the data register. Reads and writes of the data register always have the msb in bit 7.<br>0 Data is transferred most significant bit first.<br>1 Data is transferred least significant bit first. |

**Table 17-3. $\overline{SS}$ Input/Output Selection**

| SPIDDR Bit 4 (DDR3) | SSOE | Master Mode | Slave Mode |
|---|---|---|---|
| 0 | 0 | $\overline{SS}$ input with MODF feature | $\overline{SS}$ input |
| 0 | 1 | General-purpose input | $\overline{SS}$ input |
| 1 | 0 | General-purpose output | $\overline{SS}$ input |
| 1 | 1 | $\overline{SS}$ output | $\overline{SS}$ input |

### 17.3.1.2 SPI Control Register 2

Address MBAR + 0x0F01

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | SPISWAI | LSBFE |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 17-3. SPI Control Register 2**

**Table 17-4. SPI Control Register 2 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:5 | — | Reserved |
| 6 | SPISWAI | SPI Stop in Wait Mode—bit is used for power conservation while in wait mode.<br>0 SPI clock operates normally in wait mode<br>1 Stop SPI clock generation when in wait mode |
| 7 | SPC0 | Serial Pin Control Bit 0—working with the MSTR control bit, this bit enables bidirectional pin configurations as shown in Table 17-5. |

**Table 17-5. Bidirectional Pin Configurations**

| Pin Mode | | SPC0 | MSTR | MISO[1] | MOSI[2] | SCK[3] | $\overline{SS}$[4] |
|---|---|---|---|---|---|---|---|
| A | Normal | 0 | 0 | Slave Out | Slave In | SCK in | $\overline{SS}$ In |
| B | | | 1 | Master In | Master Out | SCK out | $\overline{SS}$ I/O |
| C | Bidirectional | 1 | 0 | Slave I/O | GP I/O[5] | SCK in | $\overline{SS}$ In |
| D | | | 1 | GP I/O | Master I/O | SCK out | $\overline{SS}$ I/O |

1 Slave output is enabled if SPIDDR bit 0 = 1, $\overline{SS}$ = 0, and MSTR = 0 (A, C).
2 Master output is enabled if SPIDDR bit 1 = 1 and MSTR = 1 (B, D).
3 SCK output is enabled if SPIDDR bit 2 = 1 and MSTR = 1 (B, D).
4 $\overline{SS}$ output is enabled if SPIDDR bit 3 = 1, SSOE = 1, and MSTR = 1 (B, D).
5 GP I/O = General-Purpose Input/Output.

### 17.3.1.3 SPI Baud Rate Register

Address MBAR + 0x0F04

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | SPPR2 | SPPR1 | SPPR0 | Reserved | SPR2 | SPR1 | SPR0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 17-4. SPI Baud Rate Register**

**Table 17-6. SPI Baud Rate Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | — | Reserved |
| 1:3 | SPPR[0:2] | SPI Baud Rate Preselection bits |
| 4 | — | Reserved |
| 5:7 | SPR[0:2] | SPI Baud Rate Selection bits |

The SPI baud rate is derived from the IPB clock. The SPI module clock divisor is calculated as following:

$$\text{SPI module clock divisor} = (\text{SPPR} + 1) \times 2^{(\text{SPR} + 1)}$$

The SPI Baud rate is calculated as following:

$$\text{SPI Baud Rate} = \frac{\text{IPB CLock}}{\text{SPI module clock divisor}}$$

Table 17-7 shows some baud rates derived from the possible IPB clock values:

**Table 17-7. SPI Baud Rate Selection**

| SPPR2 | SPPR1 | SPPR0 | SPR2 | SPR1 | SPR0 | SPI Module Clock Divisor | Baud Rate IPB 33.0 MHz | Baud Rate IPB 66.0 MHz | Baud Rate IPB 132.0 MHz |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 2 | 16.50 MHz | 33.00 MHz | 66.00 MHz |
| 0 | 0 | 0 | 0 | 0 | 1 | 4 | 8.250 MHz | 16.50 MHz | 33.00 MHz |
| 0 | 0 | 0 | 0 | 1 | 0 | 8 | 4.125 MHz | 8.250 MHz | 16.50 MHz |
| 0 | 0 | 0 | 0 | 1 | 1 | 16 | 2.063 MHz | 4.125 MHz | 8.250 MHz |
| .... | | | | | | | | | |
| 1 | 1 | 1 | 1 | 0 | 0 | 256 | 128.9 KHz | 257.8 KHz | 512.6 KHz |
| 1 | 1 | 1 | 1 | 0 | 1 | 512 | 64.45 KHz | 128.9 KHz | 257.8 KHz |
| 1 | 1 | 1 | 1 | 1 | 0 | 1024 | 32.23 KHz | 64.45 KHz | 128.9 KHz |
| 1 | 1 | 1 | 1 | 1 | 1 | 2048 | 16.1 KHz | 32.23 KHz | 64.45 KHz |

### 17.3.1.4 SPI Status Register

Address MBAR + 0x0F05

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | SPIF | WCOL | Reserved | MODF | Reserved | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 17-5. SPI Status Register**

**Table 17-8. SPI Status Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | SPIF | SPI Interrupt flag—bit sets after 8th SCK cycle in a data transfer. Bit is cleared by an SPISR register read (with SPIF set) followed by an SPI data register read or write access.<br>0 Transfer not yet complete<br>1 New data copied to SPIDR<br>The SPIF bit can set early (about 0.5 SPI_CLOCK) when using an SPI clock of less than 200KHz operation. This presents the possibility that writing new data into the SPI data register can cause a Write Collision (WCOL flag). The problem can be solved by putting a delay between the assertion of the SPIF bit and writing the next data to be transmitted to the SPI Data Register. |
| 1 | WCOL | Write Collision flag—bit indicates a serial transfer was in progress when the MCU tried to write new data into the SPI data register. The flag is cleared automatically by an SPI status register read (with WCOL set) followed by a SPI data register read or write access.<br>0 Write collision did not occur<br>1 Write collision occurred |
| 2 | — | Reserved |
| 3 | MODF | Mode Fault flag—bit sets if SS input goes low while SPI is configured as a master. Flag is cleared automatically by an SPI status register read (with MODF set) followed by a SPI control register 1 write.<br>0 Mode fault did not occur<br>1 Mode fault occurred |
| 4:7 | — | Reserved |

### 17.3.1.5 SPI Data Register

Address MBAR + 0x0F09

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 17-6. SPI Data Register**

**Table 17-9. SPI Data Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | D[0:7] | The SPI Data register is both an input and output register for SPI data.<br>Attempts to write to this register while data transfers are in progress sets the WCOL flag and disables the attempted write. Review the WCOL bit description in Table 17-8 for more information.<br>Reading data can occur anytime, from after SPIF is set, to before the end of the next transfer. If SPIF is not serviced by the end of the successive transfers, those data bytes are lost and data within SPIDR retains the first byte until SPIF is serviced. |

### 17.3.1.6 SPI Port Data Register

Address MBAR + 0x0F0D

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 17-7. SPI Port Data Register**

**Table 17-10. SPI Port Data Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7[1]<br>(Note 1) | D[0:7] | SPI Port Data bits—data written to SPIPORT drives pins only when they are configured as general-purpose outputs.<br>• Reading an input (data direction bit is clear) returns the pin level.<br>• Reading an output (data direction bit is set) returns the pin driver input level.<br>Writes do not change the state of pins 0:3 when pin is configured for SPI output.<br>SPIPORT I/O function depends upon the state of the SPE bit in SPI control register 1 and the state of each associated data direction bit in SPIDDR. |

[1] Bits 4:7 do not drive output pins. When programmed as inputs (data direction bit is set), they return 0.

### 17.3.1.7 SPI Data Direction Register

Address MBAR + 0x0F10

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | DDR7 | DDR6 | DDR5 | DDR4 | DDR3 | DDR2 | DDR1 | DDR0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pin Function | | | | | SS | SCK | MOSI | MISO |

**Figure 17-8. SPI Data Direction Register**

**Table 17-11. SPI Data Direction Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | DDR[0:7] | In SPI slave mode, SPIDDR bit 3 has no meaning or effect.<br>In SPI master mode, SPIDDR bit 3 determines if SPI port pin 3 is:<br>• An error-detect input to SPI<br>• Ageneral-purpose output<br>• Aslave select output line<br>When SPI is Enabled, MISO, MOSI, and SCK are:<br>• Inputs if expected to be inputs, regardless of associated data direction bit state.<br>• Outputs if expected to be outputs, only if associated data direction bit is set.<br>SPIDDR bits 0:7—SPI Port Data Direction Control bits<br>0 Associated pin is an input<br>1 Associated pin is an output |

## 17.4 Functional Description

### 17.4.1 General

The SPI module allows full-duplex, synchronous, serial communication between the MCU and peripheral devices. Software can poll the SPI status flags or SPI operation can be interrupt driven.

The SPI system is enabled by setting the SPI enable (SPE) bit in SPI control register 1. While SPE is set, the four associated SPI port pins are dedicated to the SPI function as:

- Slave select ($\overline{SS}$)
- Serial clock (SCK)
- Master out/slave in (MOSI)
- Master in/slave out (MISO)

While SPE is clear, SPI port pins 3, 2, 1, and 0 are general-purpose I/O (input/output) pins controlled by the SPI port data direction register.

The main element of the SPI system is the SPI data register. The 8-bit data register in the master and the 8-bit data register in the slave are linked by the MOSI and MISO pins to form a distributed 16-bit register. When a data transfer operation is performed, this 16-bit register is serially shifted eight bit positions by the SCK clock from the master; data is exchanged between the master and the slave. Data written to the master SPI data register becomes the output data for the slave, and data read from the master SPI data register after a transfer operation is the input data from the slave.

A write to the SPI data register puts data into a serial shifter. When a transfer is complete, received data is moved into a receive data register. Data may be read from this double-buffered system any time before the next transfer is complete. This 8-bit data register acts as the SPI receive data register for reads and as the SPI transmit data register for writes. A single SPI register address is used for reading data from the read data buffer and for writing data to the shifter.

The clock phase control bit (CPHA) and a clock polarity control bit (CPOL) in the SPI control register 1 select one of four possible clock formats to be used by the SPI system. The CPOL bit simply selects a non-inverted or inverted clock. The CPHA bit is used to accommodate two fundamentally different protocols by shifting the clock by a half cycle or by not shifting the clock (see Section 17.4.4, “Transmission Formats”).

The SPI can be configured to operate as a master or as a slave. When MSTR in SPI control register 1 is set, the master mode is selected; when the MSTR bit is clear, the slave mode is selected.

### 17.4.2 Master Mode

The SPI operates in master mode when the MSTR bit is set. Only a master SPI module can initiate transmissions. A transmission begins by writing to the master SPI data register. If the shift register is empty, the byte immediately transfers to the shift register. The byte begins shifting out on the MOSI pin under the control of the serial clock.

The SPR2, SPR1, and SPR0 baud rate selection bits in conjunction with the SPPR2, SPPR1, and SPPR0 baud rate preselection bits in the SPI baud rate register control the baud rate generator and determine the

speed of the shift register. The SCK pin is the SPI clock output. Through the SCK pin, the baud rate generator of the master controls the shift register of the slave peripheral.

In master mode, the function of the serial data output pin (MOSI) and the serial data input pin (MISO) is determined by the SPC0 and MSTR control bits.

The $\overline{SS}$ pin is normally an input which should remain in the inactive high state. However, in the master mode, if the associated data direction bit (SPIDDR bit 4) is set, then the $\overline{SS}$ pin is a general-purpose output or the slave select output depending on the state of the SSOE bit.

General-purpose output (SSOE = 0) or slave select output (SSOE = 1) is specified by the SSOE bit in SPI control register 1. When this pin is being used as the output pin with SPIDDR bit 4 set, the mode error function for the master is disabled (MODF in the SPI status register).

The SS output becomes low during each transmission and is high when the SPI is in the idling state. If the SS input becomes low while the SPI is configured as a master, it indicates a mode fault error where more than one master may be trying to drive the MOSI and SCK lines simultaneously. In this case, the SPI immediately clears the data direction bits associated with the MISO, MOSI (or MOMI), and SCK pins so that these pins become inputs. This mode fault error also clears the SPE and MSTR control bits and sets the mode fault (MODF) flag in the SPI status register. If the SPI interrupt enable bit (SPIE) is set when the MODF bit gets set, then an SPI interrupt sequence is also requested

When a write to the SPI data register in the master occurs, there is a half SCK-cycle delay. After the delay, SCK is started within the master. The rest of the transfer operation differs slightly, depending on the clock format specified by the SPI clock phase bit, CPHA, in SPI control register 1 (see Section 17.4.4, “Transmission Formats”).

### 17.4.3 Slave Mode

The SPI operates in slave mode when the MSTR bit in SPI control register 1 is clear. In slave mode, SCK is the SPI clock input from the master, and SS is the slave select input. Before a data transmission occurs, the $\overline{SS}$ pin of the slave SPI must be at logic 0. $\overline{SS}$ must remain low until the transmission is complete.

In slave mode, the function of the serial data output pin (MISO) and serial data input pin (MOSI) is determined by the SPC0 bit in SPI control register 2 and the MSTR control bit. While in slave mode, the SS input controls the serial data output pin; if SS is high (not selected), the serial data output pin is high impedance, and, if SS is low the msb (most significant bit) in the SPI data register is driven out of the serial data output pin. Also, if the slave is not selected (SS is high), then the SCK input is ignored and no internal shifting of the SPI shift register takes place.

Although the SPI is capable of full-duplex operation, some SPI peripherals are capable of only receiving SPI data in a slave mode. For these simpler devices, there is no serial data out pin

**NOTE**

When peripherals with full-duplex capability are used, take care not to simultaneously enable two receivers whose serial outputs drive the same system slave’s serial data output line.

As long as no more than one slave device drives the system slave's serial data output line, it is possible for several slaves to receive the same transmission from a master, although the master would not receive return information from all of the receiving slaves.

If the CPHA bit in SPI control register 1 is clear, odd numbered edges on the SCK input cause the data at the serial data input pin to be latched. Even numbered edges cause the value previously latched from the serial data input pin to shift into the LSB of the SPI shifter.

If the CPHA bit is set, even numbered edges on the SCK input cause the data at the serial data input pin to be latched. Odd numbered edges cause the value previously latched from the serial data input pin to shift into the LSB of the SPI shifter.

When CPHA is set, the first edge is used to get the most significant data bit onto the serial data output pin. When CPHA is clear and the SS input is low (slave selected), the msb of the SPI data is driven out of the serial data input pin. After the eighth shift, the transfer is considered complete and the received data is transferred into the SPI data register. To indicate transfer is complete, the SPIF flag in the SPI status register is set.

## 17.4.4 Transmission Formats

During an SPI transmission, data is transmitted (shifted out serially) and received (shifted in serially) simultaneously. The serial clock (SCK) synchronizes shifting and sampling of the information on the two serial data lines. A slave select line allows selection of an individual slave SPI device; slave devices that are not selected do not interfere with SPI bus activities. Optionally, on a master SPI device, the slave select line can be used to indicate multiple-master bus contention.

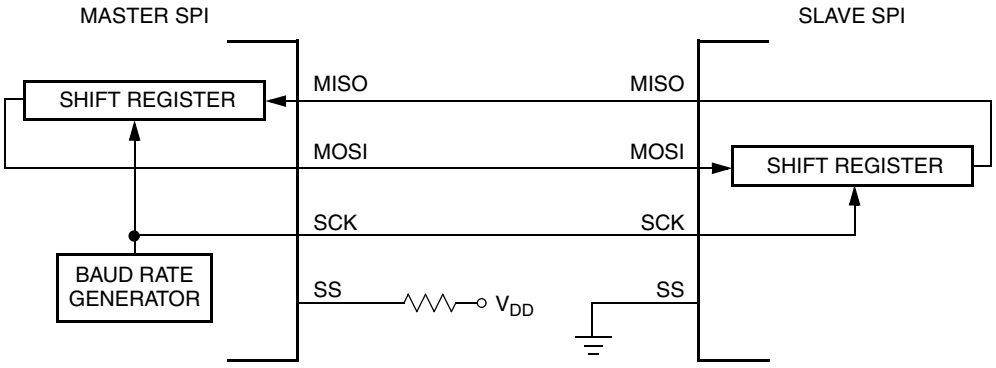



**Figure 17-9. Master/Slave Transfer Block Diagram**

### 17.4.4.1 Clock Phase and Polarity Controls

Using two bits in the SPI control register 1, software selects one of four combinations of serial clock phase and polarity.

The CPOL clock polarity control bit specifies an active high or low clock and has no significant effect on the transmission format.

The CPHA clock phase control bit selects one of two fundamentally different transmission formats.

Clock phase and polarity should be identical for the master SPI device and the communicating slave device. In some cases, the phase and polarity are changed between transmissions to allow a master device to communicate with peripheral slaves having different requirements.

### 17.4.4.2 CPHA = 0 Transfer Format

The first edge on the SCK line is used to clock the slave msb into the master and the master msb into the slave. In some peripherals, the msb of the slave's data is available at the slave data out pin as soon as the slave is selected. In this format, the first SCK edge is not issued until a half cycle into the 8-cycle transfer operation. The first edge of SCK is delayed a half cycle by clearing the CPHA bit.

The SCK output from the master remains in the inactive state for a half SCK period before the first edge appears. A half SCK cycle later, the second edge appears on the SCK line. When this second edge occurs, the value previously latched from the serial data input pin is shifted into the LSB of the shifter.

After this second edge, the next bit of the SPI master data is transmitted out of the serial data output pin of the master to the serial input pin on the slave. This process continues for a total of 16 edges on the SCK line, with data being latched on odd numbered edges and shifted on even numbered edges.

Data reception is double buffered. Data is shifted serially into the SPI shift register during the transfer and is transferred to the parallel SPI data register after the last bit is shifted in.

After the 16th (last) SCK edge:

- Data that was previously in the master SPI data register should now be in the slave data register and the data that was in the slave data register should be in the master.
- The SPIF flag in the SPI status register is set and the clock is stopped, indicating that the transfer is complete.

Figure 17-10 is a timing diagram of an SPI transfer where CPHA = 0. SCK waveforms are shown for CPOL = 0 and CPOL = 1. The diagram may be interpreted as a master or slave timing diagram since the SCK, MISO, and MOSI pins are connected directly between the master and the slave. The MISO signal is the output from the slave and the MOSI signal is the output from the master. The $\overline{SS}$ pin of the master must be either high or reconfigured as a general-purpose output not affecting the SPI.

In slave mode, if the SS line is not deasserted between the successive transmissions then the content of the SPI Data Register is not transmitted, instead the last received byte is transmitted. If the SS line is deasserted for at least minimum idle time (half SCK cycle) between successive transmissions content of the SPI Data Register is transmitted.

In master mode, with slave select output enabled the SS line is always deasserted and reasserted successive transfers for at least minimum idle time.

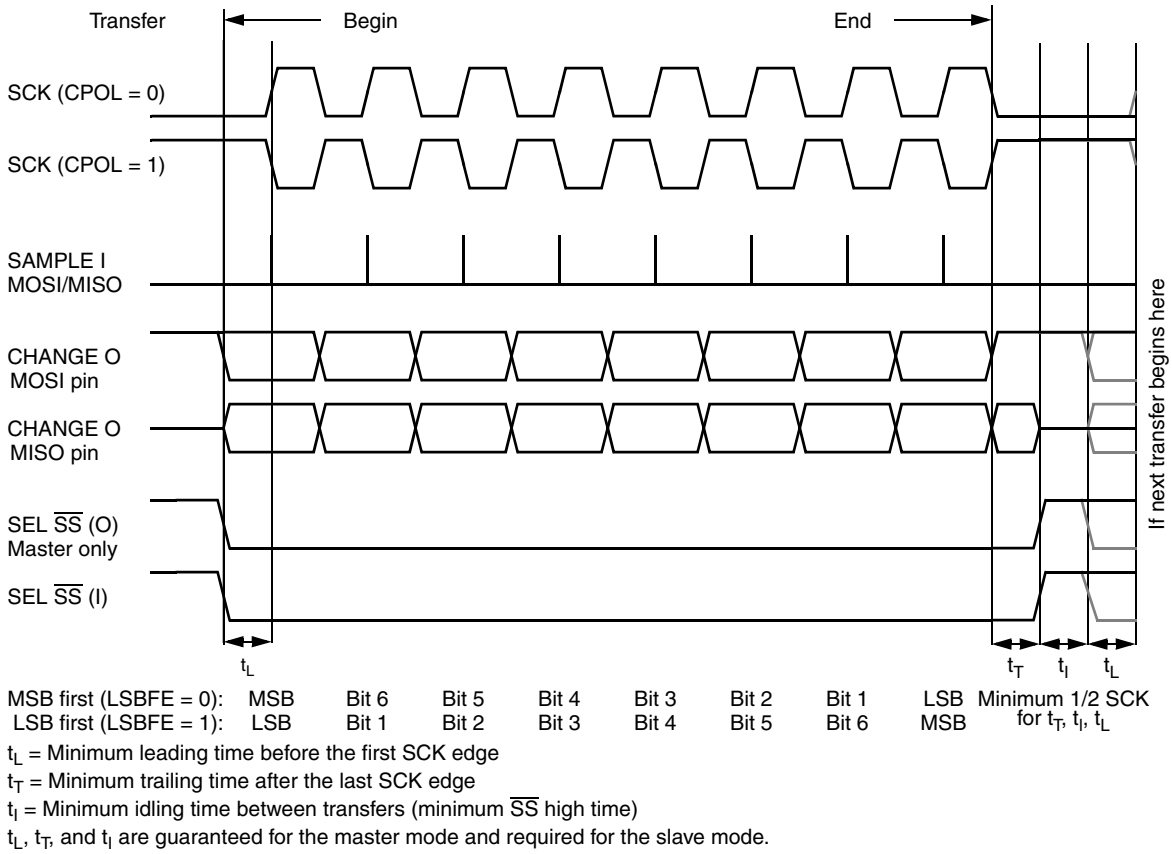

Transfer
Begin
End
SCK (CPOL = 0)
SCK (CPOL = 1)
SAMPLE I
MOSI/MISO
CHANGE O
MOSI pin
CHANGE O
MISO pin
SEL SS (O)
Master only
SEL SS (I)
If next transfer begins here
tL
tT
tI
tL
MSB first (LSBFE = 0): MSB Bit 6 Bit 5 Bit 4 Bit 3 Bit 2 Bit 1 LSB
LSB first (LSBFE = 1): LSB Bit 1 Bit 2 Bit 3 Bit 4 Bit 5 Bit 6 MSB
Minimum 1/2 SCK for tT, tI, tL
tL = Minimum leading time before the first SCK edge
tT = Minimum trailing time after the last SCK edge
tI = Minimum idling time between transfers (minimum SS high time)
tL, tT, and tI are guaranteed for the master mode and required for the slave mode.

**Figure 17-10. SPI Clock Format 0 (CPHA = 0)**

### 17.4.4.3 CPHA = 1 Transfer Format

Some peripherals require the first SCK edge before the msb becomes available at the data out pin; the second edge clocks data into the system. In this format, the first SCK edge is issued by setting the CPHA bit at the beginning of the 8-cycle transfer operation.

The first edge of SCK occurs immediately after the half SCK clock cycle synchronization delay. This first edge commands the slave to transfer its most significant data bit to the serial data input pin of the master.

A half SCK cycle later, the second edge appears on the SCK pin. This is the latching edge for both the master and slave.

When the third edge occurs, the value previously latched from the serial data input pin is shifted into the LSB of the SPI shifter. After this edge, the next bit of the master data is coupled out of the serial data output pin of the master to the serial input pins on the slave.

This process continues for a total of 16 edges on the SCK line with data being latched on even numbered edges and shifting taking place on odd numbered edges.

Data reception is double buffered; data is serially shifted into the SPI shift register during the transfer and is transferred to the parallel SPI data register after the last bit is shifted in.

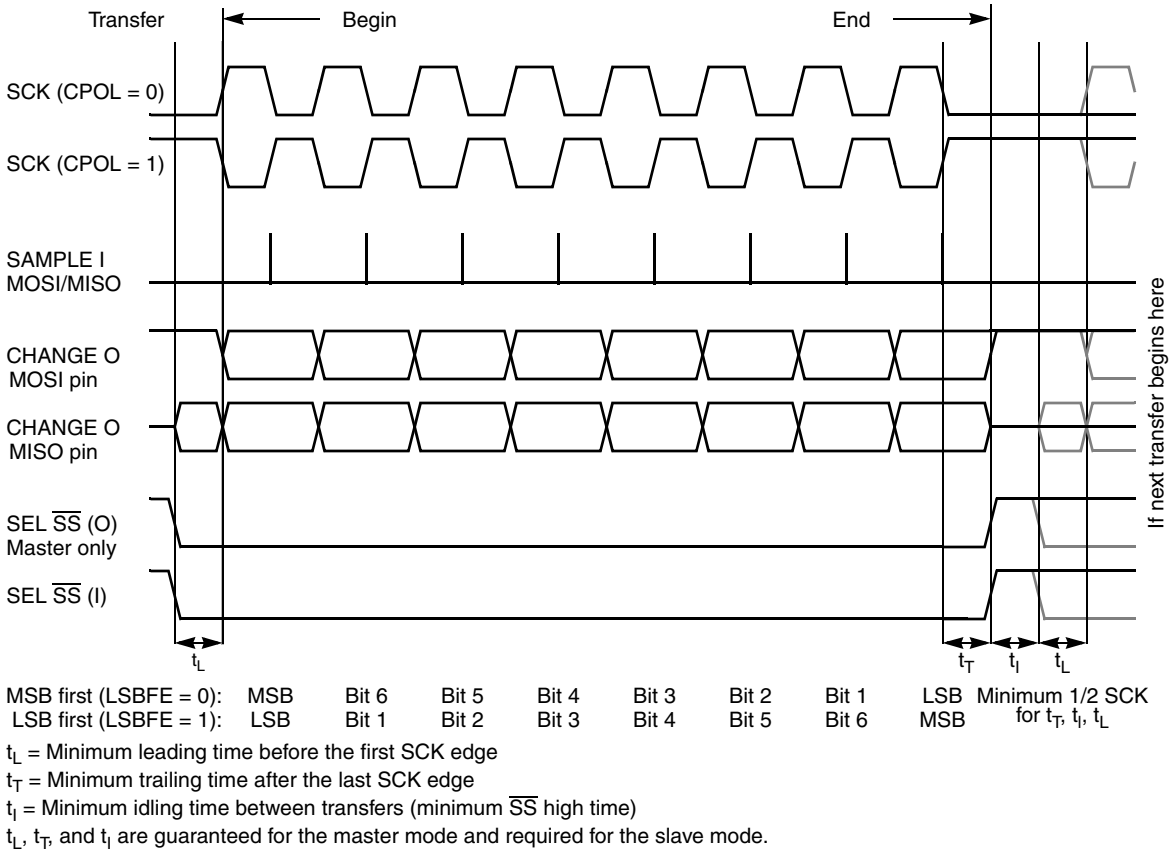
After the 16th SCK edge:

- Data that was previously in the SPI data register of the master is now in the data register of the slave, and data that was in the data register of the slave is in the master.
- The SPIF flag bit in SPISR is set and the clock is stopped, indicating that the transfer is complete.

Figure 17-11 shows two clocking variations for CPHA = 1. The diagram may be interpreted as a master or slave timing diagram since the SCK, MISO, and MOSI pins are connected directly between the master and the slave. The MISO signal is the output from the slave, and the MOSI signal is the output from the master. The SS line is the slave select input to the slave. The $\overline{SS}$ pin of the master must be either high or reconfigured as a general-purpose output not affecting the SPI.

When CPHA = 1, the SS line can remain active low between successive transfers (can be tied low at all times). This format is sometimes preferred in systems having a single fixed master and a single slave that drive the MISO data line.

The SPI interrupt request flag (SPIF) is common to both the master and slave modes. SPIF gets set after the last SCK cycle in a data transfer operation to indicate that the transfer is complete SPIF is cleared automatically when the SPI status register is read (with SPIF set) followed by a read or write to the SPI data register. If the SPIE bit is set when the SPIF flag is set, a hardware interrupt is requested.




$t_L$ = Minimum leading time before the first SCK edge
$t_T$ = Minimum trailing time after the last SCK edge
$t_I$ = Minimum idling time between transfers (minimum $\overline{SS}$ high time)
$t_L$, $t_T$, and $t_I$ are guaranteed for the master mode and required for the slave mode.

**Figure 17-11. SPI Clock Format 1 (CPHA = 1)**

A warning flag (WCOL) is set if a write to the SPI data register is attempted while a transfer is in progress. This is a conflict since the write would erroneously overwrite the current contents of the SPI serial shift register. If this situation arises, the write to the SPI data register is inhibited so as not to disturb the transfer in progress, and the WCOL flag is set to indicate the error. No interrupt is generated by WCOL because an interrupt comes at the end of the transfer that was in progress at the time of the error.

### 17.4.5 SPI Baud Rate Generation

Baud rate generation consists of a series of divider stages. Six bits in the SPI baud rate register (SPPR2, SPPR1, SPPR0, SPR2, SPR1, and SPR0) determine the divisor to the SPI module clock which results in the SPI baud rate.

The SPI clock rate is determined by the product of the value in the baud rate preselection bits (SPPR2–SPPR0) and the value in the baud rate selection bits (SPR2–SPR0). The module clock divisor equation is shown in Figure 17-12.

When all bits are clear (the default condition), the SPI module clock is divided by 2. When the selection bits (SPR2–SPR0) are 001 and the preselection bits (SPPR2–SPPR0) are 000, the module clock divisor becomes 4. When the selection bits are 010, the module clock divisor becomes 8, etc.

When the preselection bits are 001, the divisor determined by the selection bits is multiplied by 2. When the preselection bits are 010, the divisor is multiplied by 3, etc. See Table 17-7 for baud rate calculations for all bit conditions, based on a 40 MHz SPI module clock. The two sets of selects allows the clock to be divided by a non-power of two to achieve other baud rates such as divide by 6, divide by 10, etc.

The baud rate generator is activated only when the SPI is in the master mode and a serial transfer is taking place. In the other cases, the divider is disabled to decrease IDD current

$$\text{BaudRateDivisor} = (\text{SPPR} + 1) \bullet 2^{(\text{SPR} + 1)}$$

**Figure 17-12. Baud Rate Divisor Equation**

### 17.4.6 Special Features

#### 17.4.6.1 SS Output

The SS output feature automatically drives the $\overline{SS}$ pin low during transmission to select external devices and drives it high during idle to deselect external devices. When SS output is selected, the SS output pin is connected to the SS input pin of the external device.

The SS output is available only in master mode during normal SPI operation by asserting SSOE and SPIDDR bit 4 as shown in Table 17-3.

The mode fault feature is disabled while SS output is enabled.

**NOTE**

Care must be taken when using the SS output feature in a multimaster system since the mode fault feature is not available for detecting system errors between masters.

### 17.4.6.2 Bidirectional Mode (MOMI or SISO)

The bidirectional mode is selected when the SPC0 bit is set in SPI control register 2 (see Table 17-12). In this mode, the SPI uses only one serial data pin for the interface with external device(s). The MSTR bit decides which pin to use. The MOSI pin becomes the serial data I/O (MOMI) pin for the master mode, and the MISO pin becomes serial data I/O (SISO) pin for the slave mode The MISO pin in the master mode and MOSI pin in the slave mode become general-purpose I/O.

The direction of each serial I/O pin depends on the corresponding data direction register bit If the pin is configured as an output, serial data from the shift register is driven out on the pin. The same pin is also the serial input to the shift register.

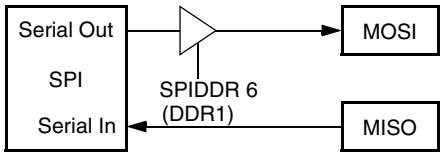
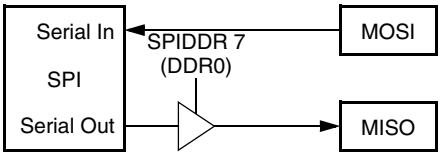
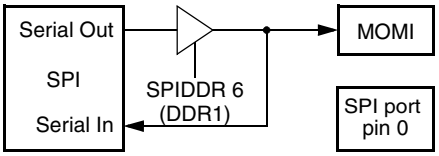
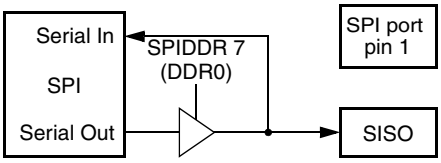
If the pin is configured as an input, serial data from the shift register is discarded, but the external serial data through the pin is the serial input to the shift register.

The SCK is output for the master mode and input for the slave mode.

The SS is the input or output for the master mode, and it is always the input for the slave mode.

The bidirectional mode does not affect SCK and SS functions; however, the SPIDDR bit 7 is not cleared by the mode fault error in the bidirectional mode.

**Table 17-12. Normal Mode and Bidirectional Mode**

| When SPE = 1 | Master Mode MSTR = 1 | Slave Mode MSTR = 0 |
|---|---|---|
| **Normal Mode SPC0 = 0** |  SWOM enables open drain output. |  SWOM enables open drain output. |
| **Bidirectional Mode SPC0 = 1** |  SWOM enables open drain output.<br>SPI port pin 7 becomes general-purpose I/O. |  SWOM enables open drain output.<br>SPI port pin 6 becomes general-purpose I/O. |

## 17.4.7 Error Conditions

The SPI has two error conditions:

- Write collision error
- Mode fault error

### 17.4.7.1 Write Collision Error

The WCOL status flag in the SPI status register indicates that a serial transfer was in progress when the MCU tried to write new data into the SPI data register. The following list explains valid write times (reference Figure 17-10 and Figure 17-11 for definitions of tT and tI).

- In Master Mode, a valid write is defined as any write within tI (when SS is high).
- In Slave Phase 0, a valid write is defined as any write within tI (when SS is high).
- In Slave Phase 1, a valid write is defined as any write within tT or tI (after last SCK edge to when SS goes low) excluding the first two module clocks after the last SCK edge (beginning of tT is an illegal write).

A write during any other time will result in a WCOL error. The MCU write is disabled to avoid writing over the data being transmitted. No interrupt is generated because the error status flag can be read upon completion of the transfer that was in progress at the time of the error. This flag is cleared automatically by a read of the SPI status register (with WCOL set) followed by a read or write access to the SPI data register.

### 17.4.7.2 Mode Fault Error

If the SS input becomes low while the SPI is configured as a master, it indicates a system error where more than one master may be trying to drive the MOSI and SCK lines simultaneously. This condition is not permitted in normal operation; the MODF bit in the SPI status register is set automatically.

In the special case where SPIDDR bit 4 is set, the $\overline{SS}$ pin is either a general-purpose output pin or SS output pin rather than being dedicated as the SS input for the SPI system. In this special case, the mode error function is inhibited and MODF remains cleared.

When a mode fault error occurs, the SPE and MSTR bits are cleared and data direction bits controlling the output enable for the SCK, MISO, and MOSI (or MOMI) pins are cleared. This forces those pins to be high impedance inputs to avoid any possibility of conflict with another output driver.

If the mode fault error occurs in the bidirectional mode, the data direction bit associated with MISO (SISO) is not affected, since this bit is dedicated for general purpose.

This flag is cleared automatically by a read of the SPI status register (with MODF set) followed by a write to SPI control register 1.

## 17.4.8 Low Power Mode Options

### 17.4.8.1 SPI in Run Mode

In run mode with the SPI system enable (SPE) bit in the SPI control register clear, the SPI system is in a low-power, disabled state. SPI registers can still be accessed, but clocks to the core of this module are disabled. Since the SPI does not support other user modes (such as supervisory), any configurations to those modes will cause the SPI to act as it does in normal run mode. The supported modes are run, wait, and stop.

### 17.4.8.2 SPI in Wait Mode

SPI operation in wait mode depends upon the state of the SPISWAI bit in SPI control register 2.

- If SPISWAI is clear, the SPI operates normally when the CPU is in wait mode
- If SPISWAI is set, SPI clock generation ceases and the SPI module enters a power conservation state when the CPU is in wait mode.
  - — If SPISWAI is set and the SPI is configured for master, any transmission and reception in progress stops at wait mode entry. The transmission and reception resumes when the SPI exits wait mode.
  - — If SPISWAI is set and the SPI is configured as a slave, any transmission and reception in progress continues if the SCK continues to be driven from the master. This keeps the slave synchronized to the master and the SCK.
  - — If the master transmits several bytes while the slave is in wait mode, the slave will continue to send out bytes consistent with the its operation mode at the start of wait mode (i.e. If the slave is currently sending its SPIDR to the master, it will continue to send the same byte. Else if the slave is currently sending the last received byte from the master, it will continue to send each previous master byte).

**NOTE**

Care must be taken when expecting data from a master while the slave is in wait or stop mode. Even though the shift register will continue to operate, the rest of the SPI is shut down (i.e. a SPIF interrupt will not be generated until exiting stop or wait mode). Also, the byte from the shift register will not be copied into the SPIDR register until after the slave SPI has exited wait or stop mode. A SPIF flag and SPIDR copy is only generated if wait mode is entered or exited during a transmission. If the slave enters wait mode in idle mode and exits wait mode in idle mode, neither a SPIF nor a SPIDR copy will occur.

#### 17.4.8.3 SPI in Stop Mode

Stop mode is dependent on the system. The SPI enters stop mode when the module clock is disabled (held high or low). If the SPI is in master mode and exchanging data when the MCU enters stop mode, the transmission is frozen until the MCU exits stop mode. After stop, data to and from the external SPI is exchanged correctly. In slave mode, the SPI will stay synchronized with the master.

The stop mode is equivalent to the wait mode with the SPISWAI bit set except that the stop mode is not dependent on the SPISWAI bit.

### 17.4.9 SPI Interrupts

The Serial Peripheral Interface only originates interrupt requests. The following is a description of how the Serial Peripheral Interface makes a request and how the MCU should acknowledge that request. The interrupt vector offset and interrupt priority are chip dependent.

#### 17.4.9.1 MODF Description

MODF occurs when the master detects an error on the $\overline{SS}$ pin. The master SPI must be configured for the MODF feature (see Table 17-3). Once MODF is set, the current transfer is halted and the following bits are changed:

- SPE=0, The SPI automatically disables itself.
- MSTR=0, The master bit in SPICR1 resets.

The MODF interrupt is reflected in the status register MODF flag. Clearing the flag will also clear the interrupt. This interrupt will stay active while the MODF flag is set. MODF has an automatic clearing process which is described in Section 17.3.1.4, “SPI Status Register”.

#### 17.4.9.2 SPIF Description

SPIF occurs when the SPI receives/transmits the last SCK edge in a data transfer operation. Once SPIF is set, it does not clear until it is serviced. SPIF has an automatic clearing process which is described in Section 17.3.1.4, “SPI Status Register” In the event that the SPIF is not serviced before the end of the next transfer (i.e., SPIF remains active throughout another transfer), the latter transfers will be ignored and no new data will be copied into the SPIDR

# Chapter 18
# Inter-Integrated Circuit ($I^2C$)

## 18.1 Overview

The following sections are contained in this document:

- Section 18.2, “I2C Controller”
- Section 18.3, “Memory Map and Register Definitions”
- Section 18.4, “Initialization Sequence”
- Section 18.5, “Transfer Initiation and Interrupt”

The Inter-Integrated Circuit ($I^2C$) is a two-wire, bidirectional serial bus that provides a simple, efficient method for data exchange between devices. This two-wire bus minimizes the interconnection between devices.

The MPC5200B contains 2 identical and independent $I^2C$ modules:

- I2C1 = MBAR + 0x3D00
- I2C2 = MBAR + 0x3D40

The $I^2C$ module is connected to the IP bus, and the CommBus.

Each module operates up to 100 Kbps with a maximum bus load and timing. Both $I^2C$ modules are capable of operating at higher baud rates, up to a maximum of clock/20, with reduced bus loading.

The maximum communication length and the number of devices that can be connected are limited by a maximum bus capacitance of 400 pF. This bus is suitable for applications requiring occasional communications over a short distance between a number of devices. It also provides flexibility, allowing more devices to be connected to the bus for further expansion and system development.

$I^2C$ is a true multi-master bus including collision detection and arbitration to prevent data corruption if two or more masters attempt to control the bus simultaneously. This feature provides the capability for complex applications with multi-processor control. It may also be used for rapid testing and alignment of end products via external connections to an assembly-line computer.

### 18.1.1 Features

The $I^2C$ module has the following key features:

- Compatible with $I^2C$ bus standard
- Multi-master operation
- Software programmable for one of 71 different serial clock frequencies
- Software selectable acknowledge bit
- Interrupt driven Byte-by-Byte data transfer
- Arbitration loss with automatic mode switching from master to slave
- Calling address identification interrupt
- Start and stop signal generation/detection
- Repeated start signal generation
- Acknowledge bit generation/detection
- Bus busy detection
- Programmable Glitch Filter

Figure 18-1 shows a block diagram of the $I^2C$ module.

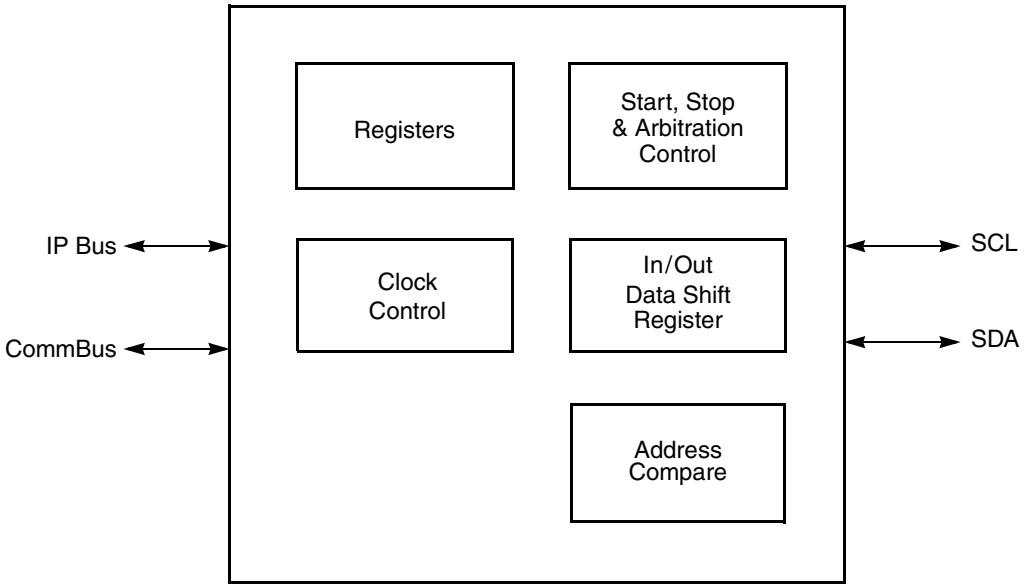



**Figure 18-1. Block Diagram—$I^2C$ Module**

## 18.2 I²C Controller

The I²C has simple bidirectional two-wire bus for efficient inter-IC control. The two wires, serial data line (SDA) and serial clock line (SCL), carry information between MPC5200B and other devices connected to the bus. Each device, including MPC5200B, is recognized by a unique address, and can operate as either transmitter or receiver, depending on the function of the device. In addition to the transmitters and receivers, devices can be considered as masters or slaves. A master is the device which initiates a data transfer on the bus and generates the clock signals to permit that transfer. At that time, any device addressed is considered a slave. See Table 18-1.

**Table 18-1. I²C Terminology**

| Term | Description |
|---|---|
| Transmitter | Device that sends data to bus. |
| Receiver | Device that receives data from bus. |
| Master | Device that initiates transfer, generates SCL, and terminates transfer. |
| Slave | Device that is addressed by master. |

Standard communication usually has 4 functional areas:

- START signal
- slave address transmission
- data transfer
- STOP signal

Activities listed above are briefly described in the sections below. Also see Figure 18-1.

### 18.2.1 START Signal

A START signal is defined as a high-to-low transition of SDA while SCL is high. This signal denotes the beginning of a new data transfer and wakes up all slaves. Each data transfer may contain several data bytes.

When the bus is free, (i.e., no master device is engaging the bus) both SCL and SDA lines are at a logical high. A master initiates communication by sending a START signal.

### 18.2.2 STOP Signal

A STOP signal is defined as a low-to-high transition of SDA while SCL is high.

The master terminates communication by generating a STOP signal, which frees the bus. The master can generate a STOP even if the slave has generated an acknowledge, at which point the slave must release the bus.

The master can generate a START signal followed by a calling command without generating a STOP signal first. This is called repeated START.

### 18.2.2.1 Slave Address Transmission

The first byte of data transfer immediately after a START signal is the slave address transmitted by the master. This is a 7-bit calling address followed by a R/$\overline{W}$ bit. The R/$\overline{W}$ bit tells the slave the desired direction of data transfer.

- 0 = Write transfer
- 1 = Read transfer

Only a slave with a calling address matching the address transmitted by the master will respond by sending back an acknowledge bit. This is done by pulling SDA low at the 9th clock. See Figure 18-2.

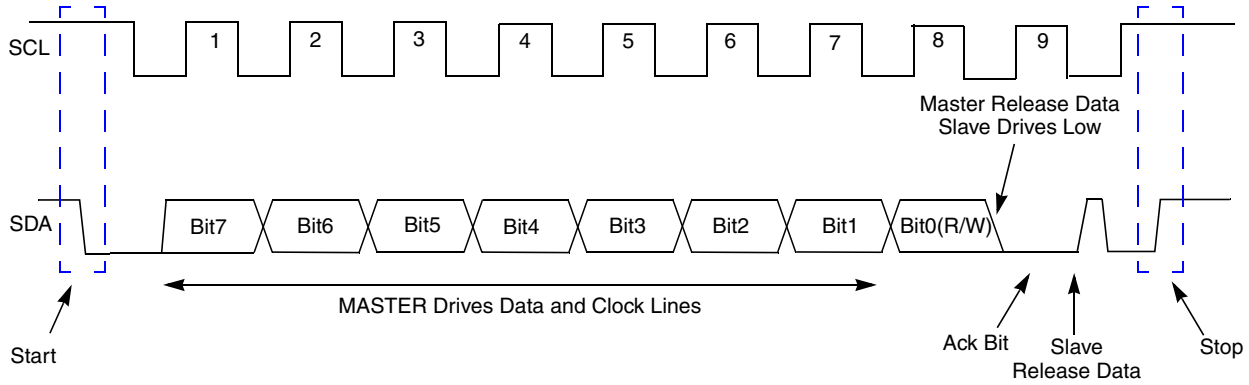



**Figure 18-2. Timing Diagram—Start, Address Transfer and Stop Signal**

### 18.2.2.2 Data Transfer

Data transfer proceeds Byte-by-Byte in a direction specified by the R/$\overline{W}$ bit sent by the calling master. Each data byte is 8bits long. Data may be changed only while SCL is low and must be held stable while SCL is high.

There is one clock pulse on SCL for each data bit. The MSB is transferred first. Each data byte must be followed by an acknowledge bit, which is signalled from the receiving device by pulling SDA low at the 9th clock. One complete data byte transfer needs nine clock pulses. See Figure 18-3.

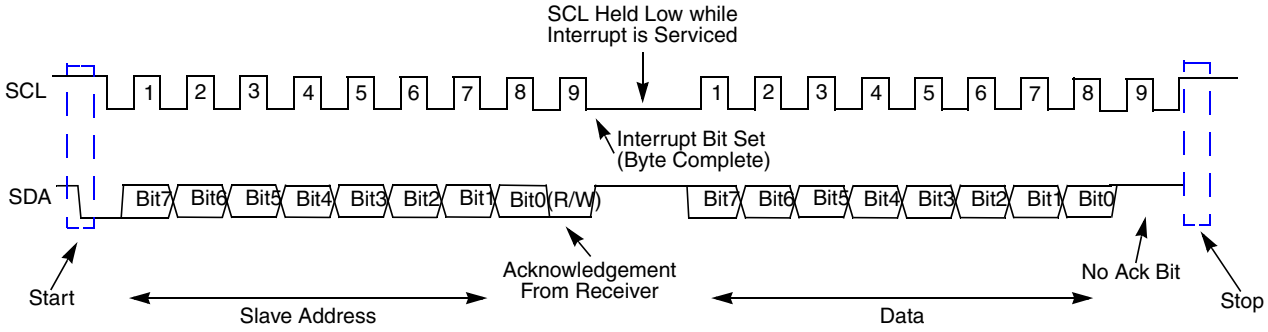



**Figure 18-3. Timing Diagram—Data Transfer**

### 18.2.2.3 Acknowledge

Figure 18-4 shows the transmitter releases the SDA line HIGH during the acknowledge clock pulse. The receiver pulls the SDA line low during the acknowledge clock pulse so that it remains stable LOW during the clock pulse high period.

If a slave-receiver does not acknowledge the byte transfer, SDA must be left HIGH by the slave. The master then generates a STOP condition to abort the transfer.

If a master-receiver does not acknowledge the slave transmitter after a byte transmission, it means End-Of-Data (EOD) to the slave. The slave then releases the SDA line for the master to generate a STOP or START signal.

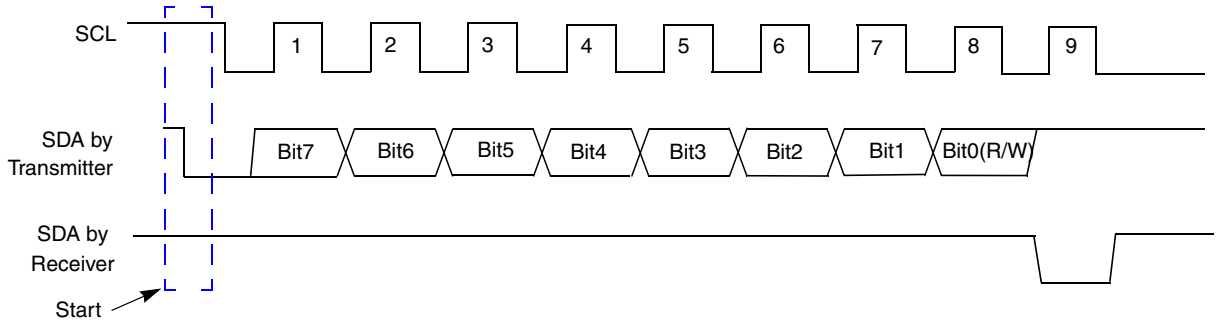



**Figure 18-4. Timing Diagram—Receiver Acknowledgement**

### 18.2.2.4 Repeated Start

A repeated START signal is a START signal generated without first generating a STOP signal to terminate the communication. The master uses this means to communicate with another slave or with the same slave in a different mode without releasing the bus.

Various combinations of read/write formats are possible. Figure 18-5 shows examples of:

- The master-transmitter transmitting to a slave-receiver. The transfer direction is not changed.
- The master reading a slave immediately after first byte. At the moment of the first acknowledge, the master-transmitter becomes a master-receiver and the slave-receiver becomes a slave-transmitter.
- The START condition and slave address are both repeated using the repeated START signal. This communicates with same slave in a different mode without releasing the bus. The master transmits data to the slave first, then the master reads data from the slave by reversing the R/$\overline{W}$ bit.

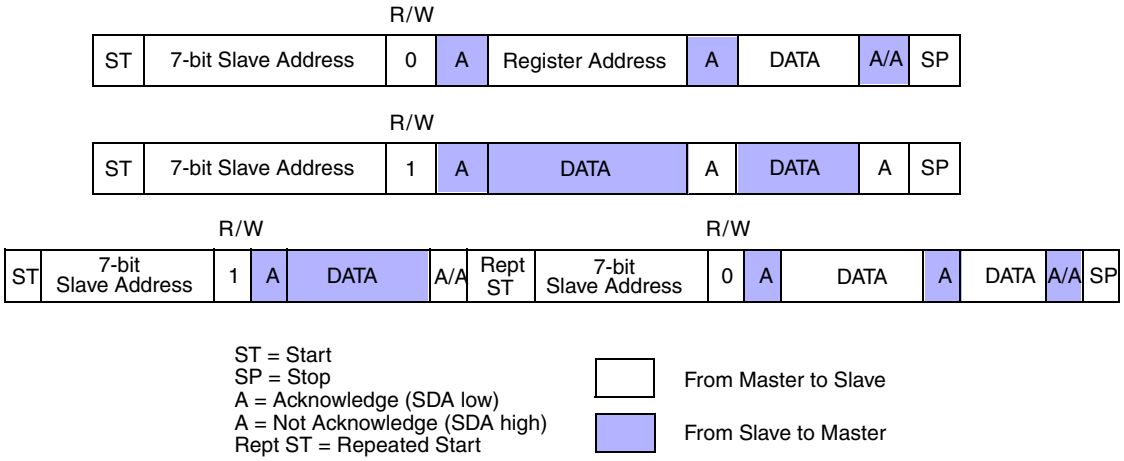



**Figure 18-5. Data Transfer, Combined Format**

### 18.2.2.5 Clock Synchronization and Arbitration

$I^2C$ is a true multi-master bus; more than one master can be connected to the bus. If two or more masters try to control the bus at the same time, a clock synchronization procedure determines the bus clock.

Since wire-AND logic is used on the SCL line, a high-to-low transition on the SCL line affects all devices connected on the bus. The devices start counting their low period. Once a device clock goes low, it holds the SCL line low until the clock high state is reached. However, the change of low-to-high in this device clock may not change the SCL line state if another device clock is still within its low period. Therefore, the synchronized clock SCL is held low by the device with the longest low period. Devices with shorter low periods enter a high wait state during this time. See Figure 18-6.

When all devices concerned have counted off their low period, the synchronized clock SCL line is released and pulled high. No difference exists between device clocks and the SCL line state. All devices start counting their high periods. The first device to complete its high period pulls the SCL line low again.

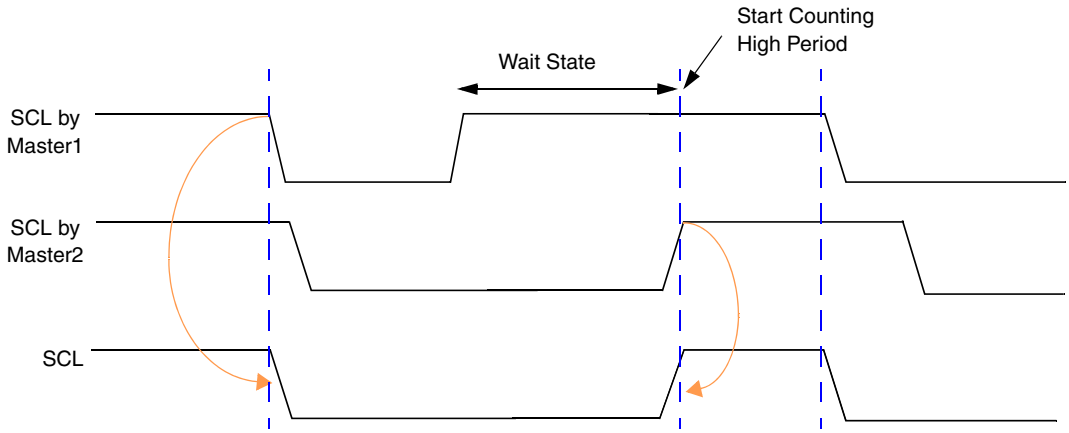



**Figure 18-6. Timing Diagram—Clock Synchronization**

A data arbitration procedure determines the relative priority of contending masters. A bus master loses arbitration if it transmits logic “1” while another master transmits logic “0”. Losing masters immediately switch to slave-receive mode and stop driving SDA output. In this case, transition from master to slave mode does not generate a STOP condition. A status bit is hardware set to indicate loss of arbitration. See Figure 18-7.

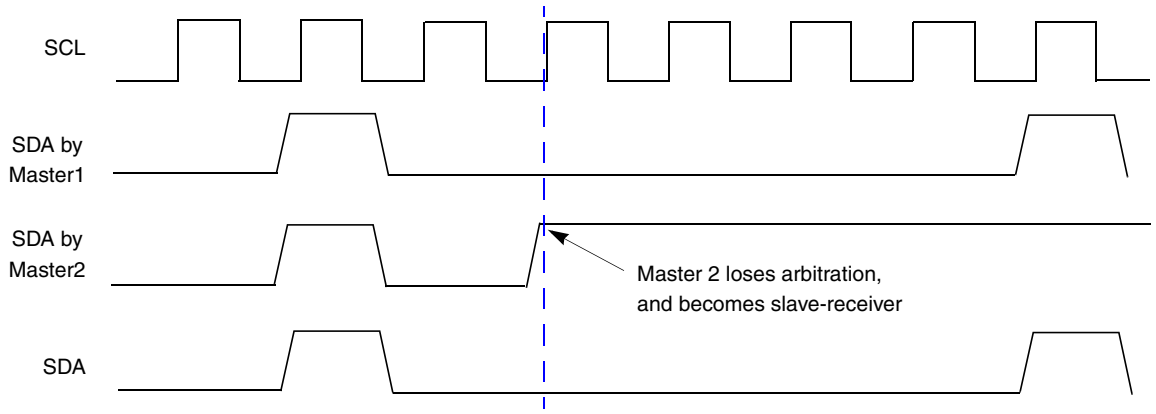



**Figure 18-7. Timing Diagram—Arbitration Procedure**

## 18.3 Memory Map and Register Definitions

The $I^2C$ is controlled by seven 32-bit registers. The registers are located at an offset from MBAR of 0x3D00 (I2C1) and 0x3D40 (I2C2). Register addresses are relative to this offset. There is one $I^2C$ Interrupt Control Register only for both $I^2C$ modules. There is also one glitch filter control register for both $I^2C$ modules.

### 18.3.1 Register Descriptions

Hyperlinks to the $I^2C$ Interface registers are provided below:

- I2C Address Register (MADR) (0x3D00)
- I2C Frequency Divider Register (MFDR) (0x3D04)
- I2C Control Register (MCR) (0x3D08)
- I2C Data I/O Register (MDR) (0x3D10)
- I2C Interrupt Control Register (0x3D20)
- I2C Filter Register (MIFR) (0x3D24)
- I2C Status Register (MSR) (0x3D0C)

### 18.3.1.1 I²C Address Register (MADR)

Address MBAR + 0x3D00/0x3D40

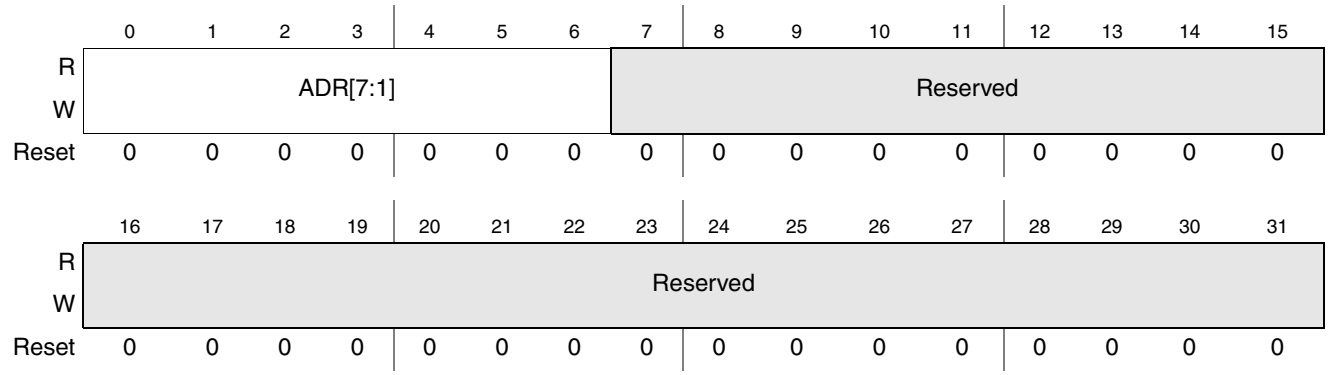



**Figure 18-8. I²C Address Register**

**Table 18-2. I²C Address Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:6 | ADR[7:1] | Bits 0 to 6 contains the address I²C responds to, when addressed as a slave.<br>**Note:** This is not the address sent on the bus during address transfer. |
| 7:31 | — | Reserved |

### 18.3.1.2 I²C Frequency Divider Register (MFDR)

Address MBAR + 0x3D04/0x3D44

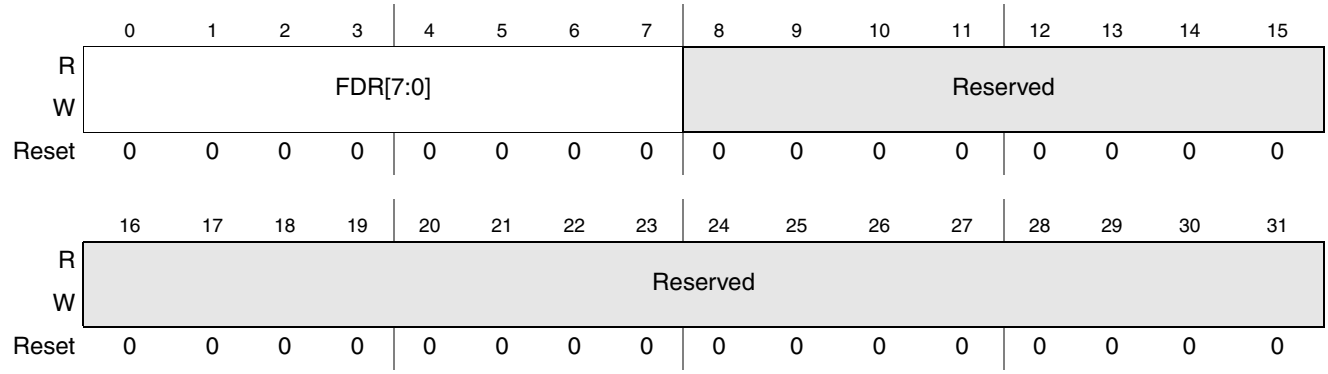



**Figure 18-9. I²C Frequency Divider Register**

**Table 18-3. I²C Frequency Divider Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | FDR[7:6] | These 2 bits act as a prescale divider of the input module clock. |
| 2:7 | FDR[5:0] | This field is used to prescale the clock for bit-rate selection. |
| 8:31 | — | Reserved |

The Frequency Divide register determines the SCL or serial bit-clock frequency. Table 18-4 must be used to select FDR bits that produce an appropriate SCL. The following relationships (1) through (4), which illustrate the connection between Table 18-4 and the signals in the $I^2C$ timing specification, are as follows:

SCL (in kHz) = (1/1000) * [system clock speed (in Hz)] / (SCL period) (1)

SDA Hold Time (in us) = 1000 * (SDA Hold / SCL Period) / [SCL (in kHz)] (2)

SCL Hold Time of START (in us) = 1000 * (SDA Hold of START / SCL Period) / [SCL (in kHz)] (3)

SCL Hold Time of STOP (in us) = 1000 * (SDA Hold of STOP / SCL Period) / [SCL (in kHz)] (4)

The following figure illustrates the relationship between system clock and the $I^2C$ signals.

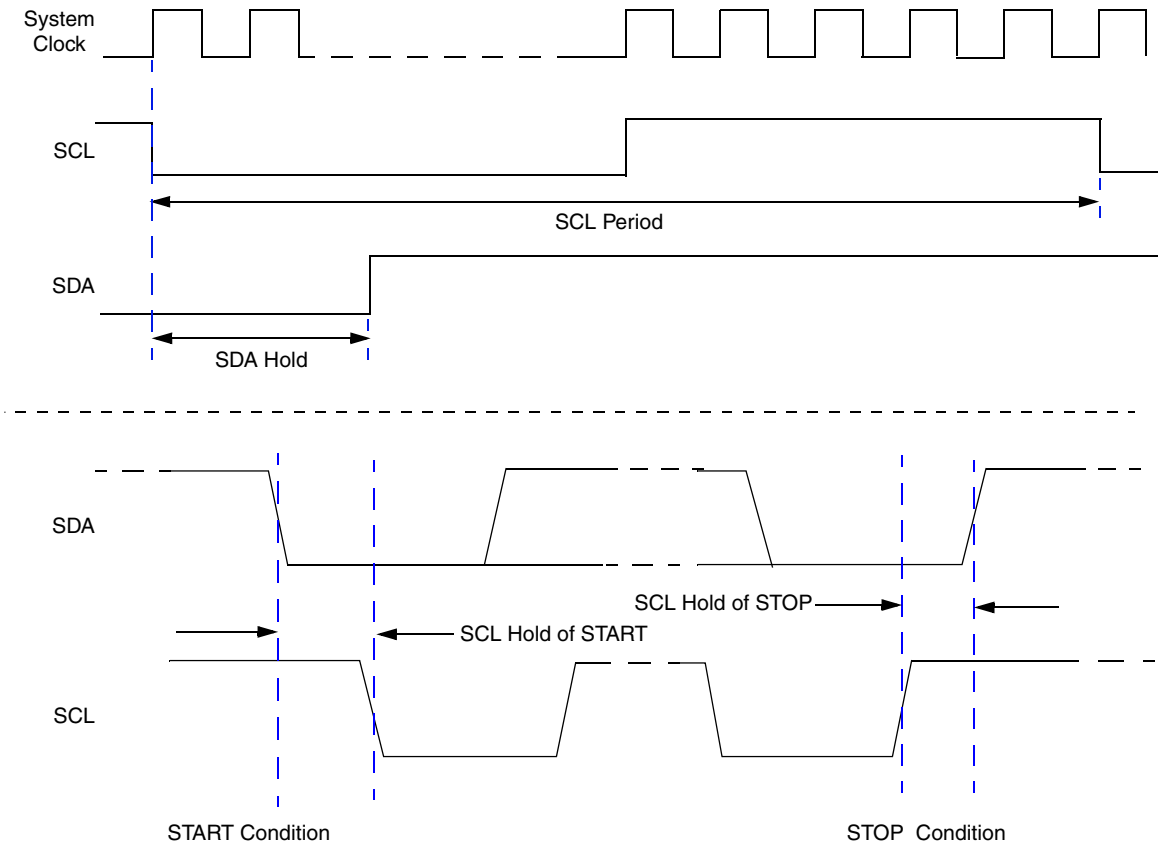



**Figure 18-10. Timing Diagram of $I^2C$ Signal Relationships**

For standard mode $I^2C$, the $I^2C$ specification states that

(SCL <= 100 kHz)

AND

(0.3 us <= SDA Hold Time <= 3.45 us)

AND

(SCL Hold of START >= 4 us)

AND

(SCL Hold of STOP >= 4 us)

which means that the system programmer must choose SCL Period, SDA Hold, SCL Hold of START, and SCL Hold of STOP from Table 18-4 to satisfy the following four equations (5) through (8):

SCL Period >= (1/100,000) * [system clock speed (in Hz) (5)

AND

(0.0003)*[SCL (in kHz)]*(SCL Period) <= SDA Hold <= (0.00345)*[SCL (in kHz)]*(SCL Period) (6)

AND

SCL Hold of START >= (0.004)*[SCL (in kHz)]*(SCL Period) (7)

AND

SCL Hold of STOP >= (0.004)*[SCL (in kHz)]*(SCL Period) (8)

In this case, the simplest strategy for the system programmer to follow is this:

1. Identify all rows of Table 18-4 where SCL Period satisfies criteria (5). This set of rows limits the choices of SCL allowed for this particular system clock.
2. Calculate the SCL associated with these rows according to (1), and decide which speeds are “acceptable” (fast enough or slow enough) for the system.
3. Then, find the subset of those rows associated with the “acceptable” $I^2C$ clock speeds such that SDA Hold satisfies criteria (6).
4. Choose the preferred FDR setting from among that subset that meets (5) and (6).
5. Check that the preferred FDR setting also satisfies (7) and (8) - usually it does. If not, then choose a different FDR setting that meets (5), (6), (7), and (8).

Likewise, for fast mode $I^2C$, the $I^2C$ specification states that

(SCL <= 400 kHz)

AND

(0.3 us <= SDA Hold Time <= 0.9 us)

AND

(SCL Hold of START >= 0.6 us)

AND

(SCL Hold of STOP >= 0.6 us)

which means that the system programmer must choose SCL Period, SDA Hold, SCL Hold of START, and SCL Hold of STOP from Table 18-4 to satisfy the following four equations (9) through (12):

SCL Period >= (1/400,000) * [system clock speed (in Hz) (9)

AND

(0.0003)*[SCL (in kHz)]*(SCL Period) <= SDA Hold <= (0.0009)*[SCL (in kHz)]*(SCL Period) (10)

AND

SCL Hold of START >= (0.0006)*[SCL (in kHz)]*(SCL Period) (11)

AND

SCL Hold of STOP >= (0.0006)*[SCL (in kHz)]*(SCL Period) (12)

In this case, the simplest strategy for the system programmer to follow is this:

1. Identify all rows of Table 18-4 where SCL Period satisfies criteria (9). This set of rows limits the choices of SCL allowed.
2. Calculate the SCL associated with these rows according to (1), and decide which speeds are “acceptable” (fast enough or slow enough) for the system.
3. Then, find the subset of those rows associated with the “acceptable” $I^2C$ clock speeds such that SDA Hold satisfies criteria (10).
4. Choose the preferred FDR setting from among that subset that meets (9) and (10).
5. Check that the preferred FDR setting also satisfies (11) and (12) — usually it does. If not, then choose a different FDR setting that meets (9), (10), (11), and (12).

As a final note, the programmer should be aware of the order of the FDR bits in Table 18-4. Additionally there may be several different combinations of FDR bits that satisfy the system programmer, because Table 18-4 has duplicated entries.

**Table 18-4. $I^2C$ Frequency Divider Bit Selection (Sheet 1 of 5)**

| FDR[7,6] | FDR[5,1,0] | FDR[4,3,2] | SCL Period | SDA Hold | SCL Hold of START | SCL Hold of STOP |
|---|---|---|---|---|---|---|
| 00 | 000 | 000 | 28 | 9 | 10 | 15 |
| 00 | 000 | 001 | 44 | 11 | 18 | 23 |
| 00 | 000 | 010 | 80 | 17 | 34 | 41 |
| 00 | 000 | 011 | 144 | 25 | 70 | 73 |
| 00 | 000 | 100 | 288 | 49 | 142 | 145 |
| 00 | 000 | 101 | 576 | 97 | 286 | 289 |
| 00 | 000 | 110 | 1152 | 193 | 574 | 577 |
| 00 | 000 | 111 | 2304 | 385 | 1150 | 1153 |
| 00 | 001 | 000 | 30 | 9 | 11 | 16 |
| 00 | 001 | 001 | 48 | 11 | 20 | 25 |
| 00 | 001 | 010 | 88 | 17 | 38 | 45 |
| 00 | 001 | 011 | 160 | 25 | 78 | 81 |
| 00 | 001 | 100 | 320 | 49 | 158 | 161 |
| 00 | 001 | 101 | 640 | 97 | 318 | 321 |
| 00 | 001 | 110 | 1280 | 193 | 638 | 641 |
| 00 | 001 | 111 | 2560 | 385 | 1278 | 1281 |
| 00 | 010 | 000 | 34 | 10 | 13 | 18 |
| 00 | 010 | 001 | 56 | 13 | 24 | 29 |
| 00 | 010 | 010 | 104 | 21 | 46 | 53 |
| 00 | 010 | 011 | 192 | 33 | 94 | 97 |
| 00 | 010 | 100 | 384 | 65 | 190 | 193 |
| 00 | 010 | 101 | 768 | 129 | 382 | 385 |
| 00 | 010 | 110 | 1536 | 257 | 766 | 769 |
| 00 | 010 | 111 | 3072 | 513 | 1534 | 1537 |
| 00 | 011 | 000 | 40 | 10 | 16 | 21 |
| 00 | 011 | 001 | 68 | 13 | 30 | 35 |
| 00 | 011 | 010 | 128 | 21 | 58 | 65 |
| 00 | 011 | 011 | 240 | 33 | 118 | 121 |
| 00 | 011 | 100 | 480 | 65 | 238 | 241 |
| 00 | 011 | 101 | 960 | 129 | 478 | 481 |
| 00 | 011 | 110 | 1920 | 257 | 958 | 961 |
| 00 | 011 | 111 | 3840 | 513 | 1918 | 1921 |
| 00 | 100 | 000 | 20 | 7 | 6 | 11 |
| 00 | 100 | 001 | 28 | 7 | 10 | 15 |
| 00 | 100 | 010 | 48 | 9 | 18 | 25 |
| 00 | 100 | 011 | 80 | 9 | 38 | 41 |
| 00 | 100 | 100 | 160 | 17 | 78 | 81 |
| 00 | 100 | 101 | 320 | 33 | 158 | 161 |
| 00 | 100 | 110 | 640 | 65 | 318 | 321 |

**Table 18-4. I²C Frequency Divider Bit Selection (Sheet 2 of 5)**

| FDR[7,6] | FDR[5,1,0] | FDR[4,3,2] | SCL Period | SDA Hold | SCL Hold of START | SCL Hold of STOP |
|---|---|---|---|---|---|---|
| 00 | 100 | 111 | 1280 | 129 | 638 | 641 |
| 00 | 101 | 000 | 22 | 7 | 7 | 12 |
| 00 | 101 | 001 | 32 | 7 | 12 | 17 |
| 00 | 101 | 010 | 56 | 9 | 22 | 29 |
| 00 | 101 | 011 | 96 | 9 | 46 | 49 |
| 00 | 101 | 100 | 192 | 17 | 94 | 97 |
| 00 | 101 | 101 | 384 | 33 | 190 | 193 |
| 00 | 101 | 110 | 768 | 65 | 382 | 385 |
| 00 | 101 | 111 | 1536 | 129 | 766 | 769 |
| 00 | 110 | 000 | 24 | 8 | 8 | 13 |
| 00 | 110 | 001 | 36 | 9 | 14 | 19 |
| 00 | 110 | 010 | 64 | 13 | 26 | 33 |
| 00 | 110 | 011 | 112 | 17 | 54 | 57 |
| 00 | 110 | 100 | 224 | 33 | 110 | 113 |
| 00 | 110 | 101 | 448 | 65 | 222 | 225 |
| 00 | 110 | 110 | 896 | 129 | 446 | 449 |
| 00 | 110 | 111 | 1792 | 257 | 894 | 897 |
| 00 | 111 | 000 | 26 | 8 | 9 | 14 |
| 00 | 111 | 001 | 40 | 9 | 16 | 21 |
| 00 | 111 | 010 | 72 | 13 | 30 | 37 |
| 00 | 111 | 011 | 128 | 17 | 62 | 65 |
| 00 | 111 | 100 | 256 | 33 | 126 | 129 |
| 00 | 111 | 101 | 512 | 65 | 254 | 257 |
| 00 | 111 | 110 | 1024 | 129 | 510 | 513 |
| 00 | 111 | 111 | 2048 | 257 | 1022 | 1025 |
| 01 | 000 | 000 | 56 | 18 | 20 | 30 |
| 01 | 000 | 001 | 88 | 22 | 36 | 46 |
| 01 | 000 | 010 | 160 | 34 | 68 | 82 |
| 01 | 000 | 011 | 288 | 50 | 140 | 146 |
| 01 | 000 | 100 | 576 | 98 | 284 | 290 |
| 01 | 000 | 101 | 1152 | 194 | 572 | 578 |
| 01 | 000 | 110 | 2304 | 386 | 1148 | 1154 |
| 01 | 000 | 111 | 4608 | 770 | 2300 | 2306 |
| 01 | 001 | 000 | 60 | 18 | 22 | 32 |
| 01 | 001 | 001 | 96 | 22 | 40 | 50 |
| 01 | 001 | 010 | 176 | 34 | 76 | 90 |
| 01 | 001 | 011 | 320 | 50 | 156 | 162 |
| 01 | 001 | 100 | 640 | 98 | 316 | 322 |
| 01 | 001 | 101 | 1280 | 194 | 636 | 642 |

**Table 18-4. I²C Frequency Divider Bit Selection (Sheet 3 of 5)**

| FDR[7,6] | FDR[5,1,0] | FDR[4,3,2] | SCL Period | SDA Hold | SCL Hold of START | SCL Hold of STOP |
|---|---|---|---|---|---|---|
| 01 | 001 | 110 | 2560 | 386 | 1276 | 1282 |
| 01 | 001 | 111 | 5120 | 770 | 2556 | 2562 |
| 01 | 010 | 000 | 68 | 20 | 26 | 36 |
| 01 | 010 | 001 | 112 | 26 | 48 | 58 |
| 01 | 010 | 010 | 208 | 42 | 92 | 106 |
| 01 | 010 | 011 | 384 | 66 | 188 | 194 |
| 01 | 010 | 100 | 768 | 130 | 380 | 386 |
| 01 | 010 | 101 | 1536 | 258 | 764 | 770 |
| 01 | 010 | 110 | 3072 | 514 | 1532 | 1538 |
| 01 | 010 | 111 | 6144 | 1026 | 3068 | 3074 |
| 01 | 011 | 000 | 80 | 20 | 32 | 42 |
| 01 | 011 | 001 | 136 | 26 | 60 | 70 |
| 01 | 011 | 010 | 256 | 42 | 116 | 130 |
| 01 | 011 | 011 | 480 | 66 | 236 | 242 |
| 01 | 011 | 100 | 960 | 130 | 476 | 482 |
| 01 | 011 | 101 | 1920 | 258 | 956 | 962 |
| 01 | 011 | 110 | 3840 | 514 | 1916 | 1922 |
| 01 | 011 | 111 | 7680 | 1026 | 3836 | 3842 |
| 01 | 100 | 000 | 40 | 14 | 12 | 22 |
| 01 | 100 | 001 | 56 | 14 | 20 | 30 |
| 01 | 100 | 010 | 96 | 18 | 36 | 50 |
| 01 | 100 | 011 | 160 | 18 | 76 | 82 |
| 01 | 100 | 100 | 320 | 34 | 156 | 162 |
| 01 | 100 | 101 | 640 | 66 | 316 | 322 |
| 01 | 100 | 110 | 1280 | 130 | 636 | 642 |
| 01 | 100 | 111 | 2560 | 258 | 1276 | 1282 |
| 01 | 101 | 000 | 44 | 14 | 14 | 24 |
| 01 | 101 | 001 | 64 | 14 | 24 | 34 |
| 01 | 101 | 010 | 112 | 18 | 44 | 58 |
| 01 | 101 | 011 | 192 | 18 | 92 | 98 |
| 01 | 101 | 100 | 384 | 34 | 188 | 194 |
| 01 | 101 | 101 | 768 | 66 | 380 | 386 |
| 01 | 101 | 110 | 1536 | 130 | 764 | 770 |
| 01 | 101 | 111 | 3072 | 258 | 1532 | 1538 |
| 01 | 110 | 000 | 48 | 16 | 16 | 26 |
| 01 | 110 | 001 | 72 | 18 | 28 | 38 |
| 01 | 110 | 010 | 128 | 26 | 52 | 66 |
| 01 | 110 | 011 | 224 | 34 | 108 | 114 |
| 01 | 110 | 100 | 448 | 66 | 220 | 226 |

**Table 18-4. I²C Frequency Divider Bit Selection (Sheet 4 of 5)**

| FDR[7,6] | FDR[5,1,0] | FDR[4,3,2] | SCL Period | SDA Hold | SCL Hold of START | SCL Hold of STOP |
|---|---|---|---|---|---|---|
| 01 | 110 | 101 | 896 | 130 | 444 | 450 |
| 01 | 110 | 110 | 1792 | 258 | 892 | 898 |
| 01 | 110 | 111 | 3584 | 514 | 1788 | 1794 |
| 01 | 111 | 000 | 52 | 16 | 18 | 28 |
| 01 | 111 | 001 | 80 | 18 | 32 | 42 |
| 01 | 111 | 010 | 144 | 26 | 60 | 74 |
| 01 | 111 | 011 | 256 | 34 | 124 | 130 |
| 01 | 111 | 100 | 512 | 66 | 252 | 258 |
| 01 | 111 | 101 | 1024 | 130 | 508 | 514 |
| 01 | 111 | 110 | 2048 | 258 | 1020 | 1026 |
| 01 | 111 | 111 | 4096 | 514 | 2044 | 2050 |
| 10 or 11 | 000 | 000 | 112 | 36 | 40 | 60 |
| 10 or 11 | 000 | 001 | 176 | 44 | 72 | 92 |
| 10 or 11 | 000 | 010 | 320 | 68 | 136 | 164 |
| 10 or 11 | 000 | 011 | 576 | 100 | 280 | 292 |
| 10 or 11 | 000 | 100 | 1152 | 196 | 568 | 580 |
| 10 or 11 | 000 | 101 | 2304 | 388 | 1144 | 1156 |
| 10 or 11 | 000 | 110 | 4608 | 772 | 2296 | 2308 |
| 10 or 11 | 000 | 111 | 9216 | 1540 | 4600 | 4612 |
| 10 or 11 | 001 | 000 | 120 | 36 | 44 | 64 |
| 10 or 11 | 001 | 001 | 192 | 44 | 80 | 100 |
| 10 or 11 | 001 | 010 | 352 | 68 | 152 | 180 |
| 10 or 11 | 001 | 011 | 640 | 100 | 312 | 324 |
| 10 or 11 | 001 | 100 | 1280 | 196 | 632 | 644 |
| 10 or 11 | 001 | 101 | 2560 | 388 | 1272 | 1284 |
| 10 or 11 | 001 | 110 | 5120 | 772 | 2552 | 2564 |
| 10 or 11 | 001 | 111 | 10240 | 1540 | 5112 | 5124 |
| 10 or 11 | 010 | 000 | 136 | 40 | 52 | 72 |
| 10 or 11 | 010 | 001 | 224 | 52 | 96 | 116 |
| 10 or 11 | 010 | 010 | 416 | 84 | 184 | 212 |
| 10 or 11 | 010 | 011 | 768 | 132 | 376 | 388 |
| 10 or 11 | 010 | 100 | 1536 | 260 | 760 | 772 |
| 10 or 11 | 010 | 101 | 3072 | 516 | 1528 | 1540 |
| 10 or 11 | 010 | 110 | 6144 | 1028 | 3064 | 3076 |
| 10 or 11 | 010 | 111 | 12288 | 2052 | 6136 | 6148 |
| 10 or 11 | 011 | 000 | 160 | 40 | 64 | 84 |
| 10 or 11 | 011 | 001 | 272 | 52 | 120 | 140 |
| 10 or 11 | 011 | 010 | 512 | 84 | 232 | 260 |
| 10 or 11 | 011 | 011 | 960 | 132 | 472 | 484 |

**Table 18-4. I²C Frequency Divider Bit Selection (Sheet 5 of 5)**

| FDR[7,6] | FDR[5,1,0] | FDR[4,3,2] | SCL Period | SDA Hold | SCL Hold of START | SCL Hold of STOP |
|---|---|---|---|---|---|---|
| 10 or 11 | 011 | 100 | 1920 | 260 | 952 | 964 |
| 10 or 11 | 011 | 101 | 3840 | 516 | 1912 | 1924 |
| 10 or 11 | 011 | 110 | 7680 | 1028 | 3832 | 3844 |
| 10 or 11 | 011 | 111 | 15360 | 2052 | 7672 | 7684 |
| 10 or 11 | 100 | 000 | 80 | 28 | 24 | 44 |
| 10 or 11 | 100 | 001 | 112 | 28 | 40 | 60 |
| 10 or 11 | 100 | 010 | 192 | 36 | 72 | 100 |
| 10 or 11 | 100 | 011 | 320 | 36 | 152 | 164 |
| 10 or 11 | 100 | 100 | 640 | 68 | 312 | 324 |
| 10 or 11 | 100 | 101 | 1280 | 132 | 632 | 644 |
| 10 or 11 | 100 | 110 | 2560 | 260 | 1272 | 1284 |
| 10 or 11 | 100 | 111 | 5120 | 516 | 2552 | 2564 |
| 10 or 11 | 101 | 000 | 88 | 28 | 28 | 48 |
| 10 or 11 | 101 | 001 | 128 | 28 | 48 | 68 |
| 10 or 11 | 101 | 010 | 224 | 36 | 88 | 116 |
| 10 or 11 | 101 | 011 | 384 | 36 | 184 | 196 |
| 10 or 11 | 101 | 100 | 768 | 68 | 376 | 388 |
| 10 or 11 | 101 | 101 | 1536 | 132 | 760 | 772 |
| 10 or 11 | 101 | 110 | 3072 | 260 | 1528 | 1540 |
| 10 or 11 | 101 | 111 | 6144 | 516 | 3064 | 3076 |
| 10 or 11 | 110 | 000 | 96 | 32 | 32 | 52 |
| 10 or 11 | 110 | 001 | 144 | 36 | 56 | 76 |
| 10 or 11 | 110 | 010 | 256 | 52 | 104 | 132 |
| 10 or 11 | 110 | 011 | 448 | 68 | 216 | 228 |
| 10 or 11 | 110 | 100 | 896 | 132 | 440 | 452 |
| 10 or 11 | 110 | 101 | 1792 | 260 | 888 | 900 |
| 10 or 11 | 110 | 110 | 3584 | 516 | 1784 | 1796 |
| 10 or 11 | 110 | 111 | 7168 | 1028 | 3576 | 3588 |
| 10 or 11 | 111 | 000 | 104 | 32 | 36 | 56 |
| 10 or 11 | 111 | 001 | 160 | 36 | 64 | 84 |
| 10 or 11 | 111 | 010 | 288 | 52 | 120 | 148 |
| 10 or 11 | 111 | 011 | 512 | 68 | 248 | 260 |
| 10 or 11 | 111 | 100 | 1024 | 132 | 504 | 516 |
| 10 or 11 | 111 | 101 | 2048 | 260 | 1016 | 1028 |
| 10 or 11 | 111 | 110 | 4096 | 516 | 2040 | 2052 |
| 10 or 11 | 111 | 111 | 8192 | 1028 | 4088 | 4100 |

### 18.3.1.3 I²C Control Register (MCR)

Address MBAR + 0x3D08/0x3D48

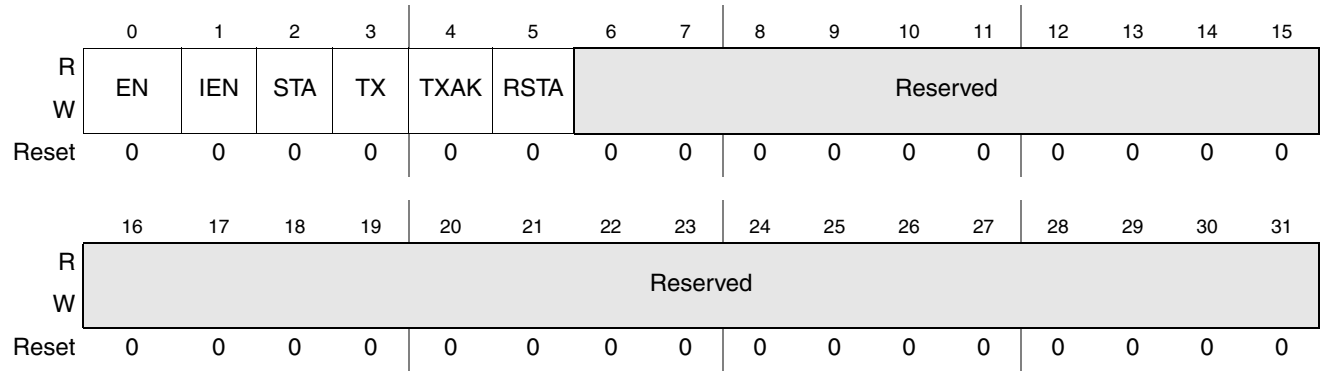



**Figure 18-11. I²C Control Register**

**Table 18-5. I²C Control Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | EN | I²C Enable—bit controls software reset of entire I²C module.<br>If I²C module is enabled in the middle of a byte transfer, interface behaves as follows:<br>• Slave mode ignores current bus transfer and starts operating when a subsequent start condition is detected.<br>• Master mode is not aware if bus is busy. If a start cycle is initiated, current bus cycle may become corrupt. Ultimately this results in the current bus master or I²C module losing arbitration, after which bus operation returns to normal.<br>0 module is reset and disabled. This is the Power-ON reset. When low the interface is held in reset, but registers can still be accessed.<br>1 I²C module is enabled. Bit must be set before other CR bits have any effect. |
| 1 | IEN | I²C Interrupt Enable<br>0 Interrupts from I²C module are disabled. This does not clear currently pending interrupt condition.<br>1 Interrupts from I²C module are enabled. An I²C interrupt occurs, provided the status register IF bit is also set. |
| 2 | STA | Master/Slave mode select—bit clears on reset.<br>• When bit changes from 0 to 1, a START signal is generated on the bus and master mode is selected.<br>• When bit changes from 1 to 0, a STOP signal is generated and operation mode changes from master to slave.<br>STA is cleared without generating a STOP signal when the master loses arbitration.<br>0 Slave Mode<br>1 Master Mode |
| 3 | TX | Transmit/Receive mode select—bit selects master/slave transfer direction.<br>• When addressed as slave, software should set according to status register SRW bit.<br>• When in master mode, bit should be set according to type of transfer required.<br>For address cycles, bit is always high.<br>0 Receive<br>1 Transmit |
| 4 | TXAK | Transmit Acknowledge enable—bit specifies value driven to SDA during acknowledge cycles for both master and slave receivers. Values are used only when I²C is a receiver, not a transmitter.<br>0 Acknowledge signal is sent to bus at 9th clock bit after receiving 1Byte of data.<br>1 No acknowledge signal response is sent (i.e., acknowledge bit = 1) |

**Table 18-5. I²C Control Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 5 | RSTA | Repeat Start—writing 1 to this bit generates a repeated START condition on the bus, provided it is the current bus master. Bit is always read low.<br>If the bus is owned by another master, attempting a repeated start at the wrong time results in loss of arbitration.<br>1 = Generate repeat start cycle |
| 6:31 | — | Reserved |

### 18.3.1.4 I²C Status Register (MSR)

Address MBAR + 0x3D0C/0x3D4C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | CF | AAS | BB | AL | AKF | SRW | IF | RXAK | Reserved | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 18-12. I²C Status Register**

**Table 18-6. I²C Status Register Field Descriptions[1]**

| Bit | Name | Description |
|---|---|---|
| 0 | CF | Data transferring—bit clears while 1 Byte of data is being transferred. Bit is set by falling edge of 9th clock of a byte transfer.<br>0 Transfer in progress<br>1 Transfer complete |
| 1 | AAS | Addressed As Slave—bit sets when its own specific address (I²C Address Register) is matched with the calling address. The CPU is interrupted provided IEN is set. The CPU then needs to check the SRW bit and set its Tx/Rx mode accordingly. Writing to the I²C Control Register clears this bit.<br>0 Not addressed<br>1 Addressed as a slave |
| 2 | BB | Bus Busy—bit indicates bus status. When a START signal is detected, BB is set. If a STOP signal is detected, it is cleared.<br>0 Bus is idle<br>1 Bus is busy |
| 3 | AL | Arbitration Lost—bit is set by hardware when the arbitration procedure is lost. Arbitration is lost in the following circumstances:<br>1. SDA sampled low when master drives high during an address or data Tx cycle.<br>2. SDA sampled low when master drives high during a data Rx cycle acknowledge bit.<br>3. Start cycle is attempted when bus is busy.<br>4. A repeated start cycle is requested in slave mode.<br>5. Stop condition is detected when not requested by master. Software must clear bit by writing it low. |

**Table 18-6. I²C Status Register Field Descriptions[1] (continued)**

| Bit | Name | Description |
|---|---|---|
| 4 | AKF | Acknowledge Cycle Falling Edge when Arbitration Lost AND Addressed as Slave - bit is set by hardware upon the falling edge of the acknowledge cycle after arbitration has been lost and addressed as slave. In this very specific case, the interrupt (IF=1) is really the 2nd one set by the hardware (which is a *side-effect* of a fix to make the I²C module fully I²C-spec compliant - *see note in section 18.5.3 Special note on AKF)*, The software must use this bit to distinguish if the interrupt is the first one (set upon rising edge of acknowledge cycle) or the second one (set upon falling edge of acknowledge cycle). The software should only take action for AL & AAS if the interrupt is the second one, the "traditional time" for the interrupt.<br>0 1st interrupt on rising edge of acknowledge cycle- software should not take AL&AAS action (*see later section for typical software flow diagram*).<br>1 2nd interrupt on falling edge of acknowledge - software should take AL&AAS action<br>This bit must be cleared by software writing it low in the interrupt routine |
| 5 | SRW | Slave Read/Write—when set, bit indicates the R/W command bit value of the calling address sent from the master.<br>**BE AWARE:** Bit is valid only when I²C is in slave mode, a complete address transfer occurred with an address match, and no other transfers were initiated. Checking this bit, the CPU can select slave Tx/Rx mode according to the master command.<br>0 Slave receive, master writing to slave<br>1 Slave transmit, master reading from slave |
| 6 | IF | I²C Interrupt—sets when an interrupt is pending. If IEN is set, a processor interrupt request is generated. IF sets when one of the following events occurs:<br>1. Complete 1 Byte transfer (set at falling edge of 9th clock).<br>2. A Rx calling address matches its own specific address in slave mode.<br>3. Arbitration is lost.<br>This bit must be cleared by software writing it low in the interrupt routine. |
| 7 | RXAK | Receive Acknowledge—SDA value during the bus cycle acknowledge bit.<br>• If bit is low, it indicates an acknowledge signal was received after completion of 8 bits of data transmission on the bus.<br>• If bit is high, it means no acknowledge signal is detected at the 9th clock.<br>0 Acknowledge received<br>1 No acknowledge received |
| 8:31 | — | Reserved |

[1] This status register is read-only with the exception of bit 6 (IF), bit4 (AKF) and bit 3 (AL), which are software clearable.

### 18.3.1.5 I²C Data I/O Register (MDR)

Address MBAR + 0x3D10/0x3D50

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 18-13. I²C Data I/O Register**

**Table 18-7. I²C Data I/O Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | D[7:0] | In Master Transmit Mode—when data is written to this register, a data transfer is initiated. The most significant bit is sent first.<br>**Note:** In this mode, the first data byte written to DR. Assertion of STA is used for the address transfer and should be comprise of the calling address (in position D[7]:D[1]) concatenated with the required R/$\overline{W}$ bit (in position D0).<br>In Master Receive Mode—reading this register initiates next byte data receiving.<br>In Slave Mode—the same functions are available after an address match occurs. |
| 8:31 | — | Reserved |

### 18.3.1.6 I²C Interrupt Control Register

Address MBAR + 0x3D20

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | BNBE2 | TE2 | RE2 | IE2 | BNBE1 | TE1 | RE1 | IE1 | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 18-14. I²C Interrupt Control Register**

**Table 18-8. I²C Interrupt Control Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | BNBE2 | Bus Not Busy Enable 2—lets module 2 generate an interrupt when the bus is not busy. BNBE2 indicates an idle condition.<br>To clear the interrupt, software must write 0 to the bit position.<br>Reset condition disables BNBE2. |
| 1 | TE2 | Transmit Enable 2—routes the interrupt for module 2 to the TX requestor at SDMA.<br>Clear by writing 0 to this bit position.<br>Reset condition disables TE2. |
| 2 | RE2 | Receive Enable 2—routes the interrupt for module 2 to the RX requestor at SDMA.<br>Clear by writing 0 to this bit position.<br>Reset condition disables RE2. |
| 3 | IE2 | Interrupt Enable 2—routes the interrupt for module 2 to the CPU.<br>Clear by writing 0 to this bit position.<br>Reset condition enables IE2. |
| 4 | BNBE1 | Bus Not Busy Enable 1—lets module 1 generate an interrupt when the bus is not busy. BNBE1 indicates an idle condition.<br>To clear the interrupt, software must write 0 to the bit position.<br>Reset condition disables this bit. |
| 5 | TE1 | Transmit Enable 1—routes the interrupt for module 1 to the TX requestor at SDMA.<br>Clear by writing 0 to this bit position.<br>Reset condition disables TE1. |
| 6 | RE1 | Receive Enable 1—routes the interrupt for module 1 to the RX requestor at SDMA.<br>Clear by writing a 0 to this bit position.<br>Reset condition disables RE1. |
| 7 | IE1 | Interrupt Enable 1—routes the interrupt for module 1 to the CPU.<br>Clear by writing 0 to this bit position.<br>Reset condition enables IE1. |
| 8:31 | — | Reserved |

The Interrupt Control register is common to both MPC5200B $I^2C$ modules. Each module generates an internal interrupt that can be routed as follows:

- To the CPU interrupt, if IE is set to 1.
- To the TX requestor at SDMA, if TE is set to 1.
- To the RX requestor at SDMA, if RE is set to 1.

Typically, only one (or none) of the above destinations would be specified. Although, it may be useful to send an interrupt to both the CPU and SDMA. Selecting between TX and RX is based on whether the module is:

- Sending data (master or slave TX)
- Receiving data (master or slave RX)

Individual requests trigger different SDMA tasks. Reset condition is, IE set and all other enable bits clear.

The BNBE bit lets the module generate an interrupt when the bus becomes not-busy. This implies receipt of a STOP condition, for which the module normally does not generate an interrupt. Because bus-not-busy is an idle condition, it is necessary for software responding to this interrupt to clear the BNBE bit to clear the interrupt condition. Otherwise, the interrupt condition persists until another $I^2C$ transaction is initiated.

### 18.3.1.7 I²C Filter Register (MIFR)

Address MBAR + 0x3D24

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | FR3 | FR2 | FR1 | FR0 | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R<br>W | Reserved | | | | | | | | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 18-15. I²C Filter Register**

**Table 18-9. I²C Filter Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:3 | — | Reserved |
| 4:7 | FR[7:4] | Bits 7 to 4 contain the programming controls for the width of glitch (in terms of IPBUS clock cycles) that the filter should absorb, that is, the filter will not let pass glitches less than or equal to this width setting.<br>FR[]<br>3210<br>0000 No Filter / Bypass<br>0001 Filter glitches up to width of 1 IPBUS clock cycle<br>0010 Filter glitches up to width of 2 IPBUS clock cycles<br>0011 Filter glitches up to width of 3 IPBUS clock cycles<br>0100 Filter glitches up to width of 4 IPBUS clock cycles<br>0101 Filter glitches up to width of 5 IPBUS clock cycles<br>0110 Filter glitches up to width of 6 IPBUS clock cycles<br>0111 Filter glitches up to width of 7 IPBUS clock cycles<br>1000 Filter glitches up to width of 8 IPBUS clock cycles<br>1001 Filter glitches up to width of 9 IPBUS clock cycles<br>1010 Filter glitches up to width of 10 IPBUS clock cycles<br>1011 Filter glitches up to width of 11 IPBUS clock cycles<br>1100 Filter glitches up to width of 12 IPBUS clock cycles<br>1101 Filter glitches up to width of 13 IPBUS clock cycles<br>1110 Filter glitches up to width of 14 IPBUS clock cycles<br>1111 Filter glitches up to width of 15 IPBUS clock cycles |
| 8:31 | — | Reserved |

An I²C glitch filter has been added outside the I²C legacy modules (but within the I²C package). This filter can absorb (or “eat”) glitches on both the I²C clock and data lines for each I²C module. The width of glitch to absorb can be specified in terms on number of IPBUS clock cycles. A single glitch filter control register is provided for both I²C modules.

The programming of the glitch filter is simple — the programmer only needs to specify the size of glitch (in terms of IPBUS clock cycles) for the filter to absorb and not pass.

## 18.4 Initialization Sequence

Reset puts the $I^2C$ Control register to its default status. Before the interface can be used to transfer serial data, the following initialization procedure must be done:

Step 1. Update the Frequency Divider register and select the required division ratio to obtain the SCL frequency from the system clock.

Step 2. Update the $I^2C$ Address register to define a slave address.

Step 3. Set the Control register EN bit to enable the $I^2C$ interface system.

Step 4. Modify the Control register bits to select master/slave mode, transmit/receive mode and interrupt enable or not.

## 18.5 Transfer Initiation and Interrupt

In master transmit mode, a data transfer is initiated when data is written to the DATA register. The most significant bit is sent first.

In master receive mode, reading this register initiates next byte data receiving.

In slave mode, the same functions as are available after an address match occurs. Data transfer is initiated by:

- Writing to the DATA register for slave transmits, or
- Adummy reading from the DATA register in slave receive mode occurs.

The $I^2C$ interrupt STATUS register bit is set when an interrupt is pending. If the CONTROL register interrupt enable bit is set, setting the $I^2C$ interrupt STATUS register bit causes a processor interrupt request. The interrupt bit sets when one of the following events occurs:

- A complete 1Byte transfer (set at falling edge of 9th clock) occurs.
- A receive calling address matches its own specific address in slave receive mode.
- Arbitration is lost.

### 18.5.1 Post-Transfer Software Response

In the interrupt service routine, software must clear the IF status bit first. The CF status bit will be cleared automatically by reading from the Data I/O Register (MBDR) in receive mode or writing to MBDR in transmit mode.

Software may service the bus I/O in the main program by monitoring the IF status bit if the interrupt function is disabled. Polling should monitor the IF status bit rather than the CF bit since their operation is different when arbitration is lost.

When an interrupt occurs at the end of the address cycle the master will always be in transmit mode, i.e. the address is transmitted. If master receive mode is required, indicated by R/W bit in the DATA register, then the TX control bit should be toggled at this stage.

During slave mode address cycles (AAS = 1) the SRW bit in the STATUS register is read to determine the direction of the subsequent transfer and the TX control bit is programmed accordingly. For slave mode, data cycles (AAS = 0) the SRW bit is not valid, therefore the TX bit in the control register should be read to determine the direction of the current transfer.

### 18.5.2 Slave Mode

In the slave interrupt service routine, the AAS bit should be tested to determine if a calling of its own address was received. If AAS is set, software should set the Tx/Rx mode select bit (Control register Tx bit) according to the R/$\overline{W}$ command bit (SRW). Writing to the CONTROL register automatically clears AAS. The slave interrupt service routine should also “move” the data, depending on whether its acting as a transmitter or a receiver, as follows: For a slave transmitter, the slave interrupt service routine must initiate a data transfer by writing information to the DATA register. For a slave receiver, the slave interrupt service routine must initiate a transfer by performing a dummy read from the DATA register. The slave drives SCL low between byte transfers. SCL is released when the DATA register is accessed in the required mode.

In slave transmitter routine, RXAK must be tested before transmitting the next data byte. Setting RXAK means an end of data signal from the master receiver. After which, software causes a switch from transmitter mode to receiver mode. A dummy read then releases the SCL line letting the master generate a STOP signal.

### 18.5.3 Special Note on AKF

A new status bit has been added to MSR[4] for the MPC5200B release of this chip. The reason for this is that the legacy $I^2C$ module was found to violate, in a merely academic sense, the $I^2C$ specification by sending out a very short 9th clock pulse after losing arbitration to another master. According to the $I^2C$ specification, the losing $I^2C$ master may only complete “one byte’s worth” of clock pulses after losing arbitration. The extra short 9th clock pulse driven by the losing $I^2C$ master was deemed to violate spec, so a fix to the module was performed to bring the module in line with spec. One “side-effect” of this fix s that for the unique situation when the $I^2C$ module both loses arbitration (AL) and is addressed as slave (AAS), the newly fixed $I^2C$ module generates two interrupt (IF) requests: one on the rising edge of the acknowledge clock pulse (which is a new time to make the interrupt request) as well as on the falling edge of the acknowledge clock pulse (which is the legacy time to do so). In order to help the software programmer distinguish the first interrupt request (which is non-legacy) from the second interrupt request (which is legacy), the AKF bit was added. The AKF bit will be set only for the 2nd interrupt. The software programmer may thus use the value of AKF (in addition to all the usual bits the software checks) to determine when to act. The following figure on typical software flow for $I^2C$ routines will illustrate clearly how the AKF bit may be used.

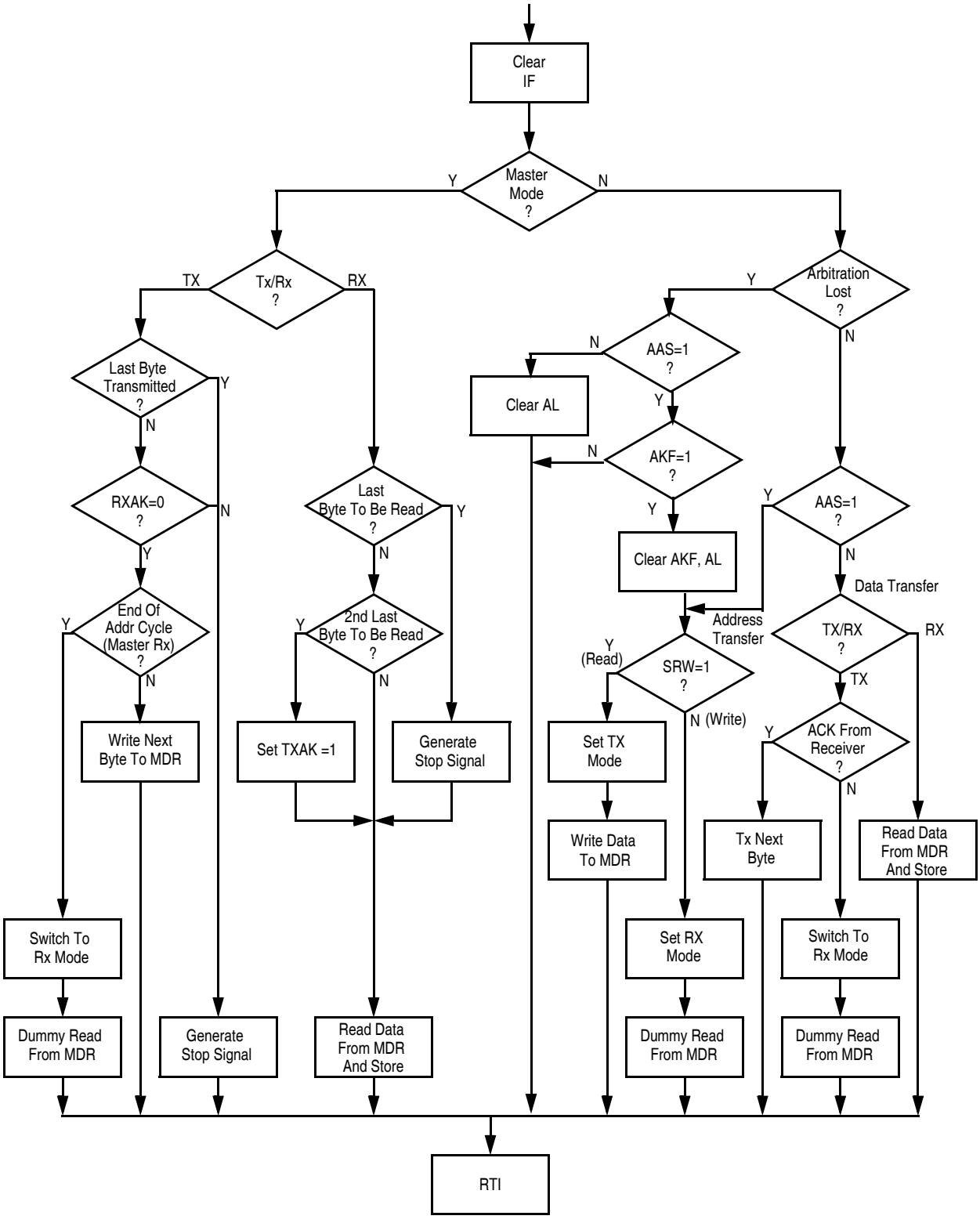



**Figure 18-16. Software Flowchart of Typical I²C Interrupt Routine**

# Chapter 19
# Controller Area Network (MSCAN)

## 19.1 Overview

The following sections are contained in this document:

- Section 19.1, “Overview”
- Section 19.2, “Features”
- Section 19.3, “External Signals”
- Section 19.4, “CAN System”
- Section 19.5, “Memory Map / Register Definition”
- Section 19.6, “Programmer’s Model of Message Storage”
- Section 19.7, “Functional Description”

The MPC5200B contains 2 identical and independent MSCAN Controller:

- MSCAN1 = MBAR + 0x0900
- MSCAN2 = MBAR + 0x0980

The Motorola Scalable Controller Area Network (MSCAN) definition is based on the MSCAN12 definition which is the specific implementation of the Motorola Scalable CAN concept targeted for the Freescale Semiconductor, Inc. (formerly Motorola) MC68HC12 Microcontroller Family.

The module is a communication controller implementing the CAN 2.0 A/B protocol as defined in the BOSCH specification dated September 1991. For users to fully understand the MSCAN specification, it is recommended that the Bosch specification be read first to familiarize the reader with the terms and concepts contained within this document.

The CAN protocol was primarily, but not only, designed to be used as a vehicle serial data bus, meeting the specific requirements of this field: real-time processing, reliable operation in the EMI environment of a vehicle, cost-effectiveness and required bandwidth.

MSCAN utilizes an advanced buffer arrangement resulting in a predictable real-time behavior and simplifies the application software.

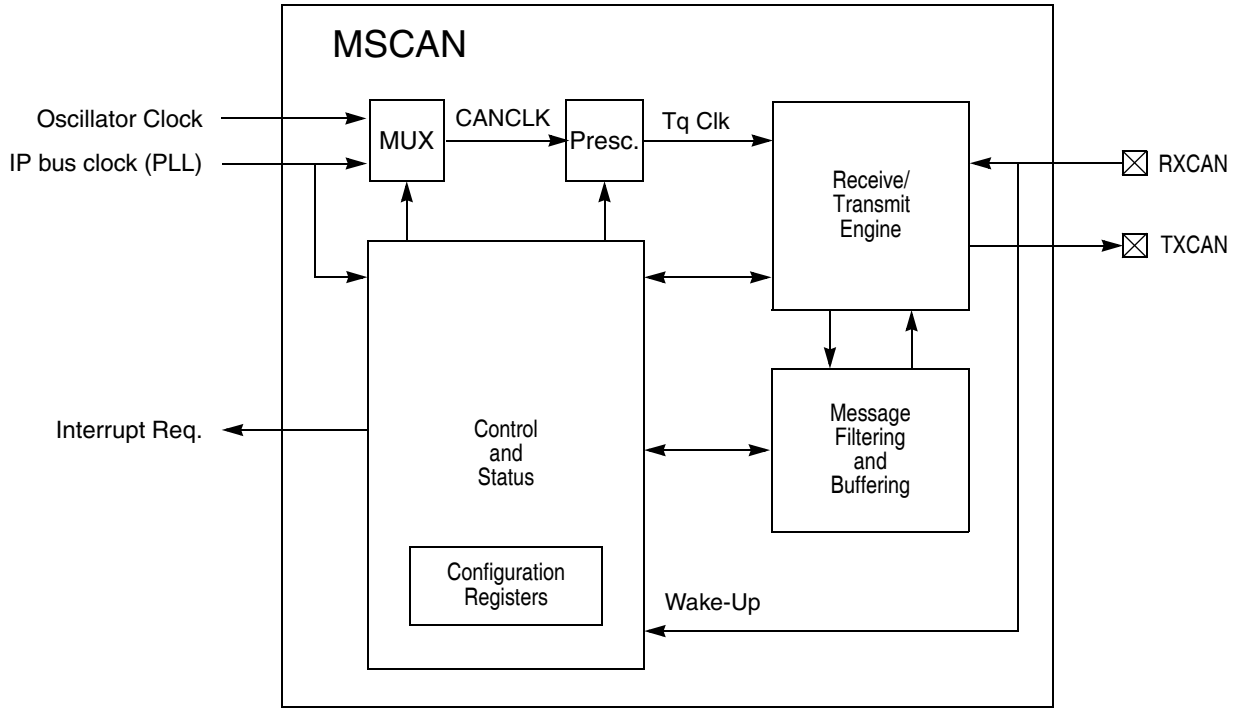



**Figure 19-1. MSCAN Block Diagram**

## 19.2 Features

The basic features of the MSCAN are as follows:

- Implementation of the CAN protocol - Version 2.0A/B
  - — Standard and extended data frames
  - — 0 - 8 bytes data length
  - — Programmable bit rate up to 1 Mbps (Depending on the actual bit timing and the clock jitter of the PLL)
  - — Support for remote frames
  - — 4 receive buffers with FIFO storage scheme
- 3 transmit buffers with internal prioritization using a “local priority” concept
- Flexible maskable identifier filter supports two full size extended identifier filters (two 32-bit) or four 16-bit filters or eight 8-bit filters
- Programmable wake-up functionality
- Programmable loop back mode supports self-test operation
- Programmable listen-only mode for monitoring of CAN bus
- Separate signalling and interrupt capabilities for all CAN receiver and transmitter error states (Warning, Error Passive, Bus-Off)
- Programmable MSCAN clock source either IP bus clock or Oscillator clock
- Internal timer for time-stamping of received and transmitted messages
- Three low power modes: Sleep, Power Down and MSCAN Disabled
- Global initialization of configuration registers

## 19.3 External Signals

The MSCAN uses two external pins. In the MPC5200B the MSCAN pins are shared with other funtionality and can be available at two different groups of pins. The configuration of the pin-muxing is controlled by the Port Configuration Register, see Section 7.

### 19.3.1 RXCAN — CAN Receiver Input Pin

RXCAN is the MSCAN receiver input pin.

### 19.3.2 TXCAN — CAN Transmitter Output Pin

TXCAN is the MSCAN transmitter output pin. The TXCAN output pin represents the logic level on the CAN bus:

0 = Dominant state

1 = Recessive state

## 19.4 CAN System

A typical CAN system with MSCAN is shown in Figure 19-2. Each CAN station is connected physically to the CAN bus lines through a transceiver chip. The transceiver is capable of driving the large current needed for the CAN bus and has current protection against defected CAN or defected stations.

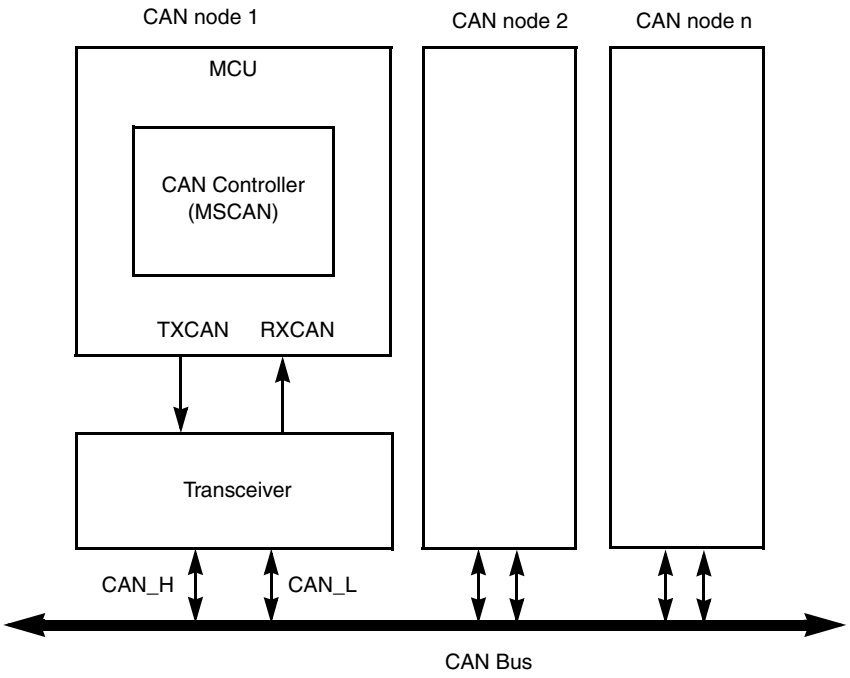



**Figure 19-2. The CAN System**

## 19.5 Memory Map / Register Definition

The MPC5200B contains 2 independent MSCAN Controller:

- MSCAN1 = MBAR + 0x0900
- MSCAN2 = MBAR + 0x0980

### 19.5.1 Module Memory Map

Table 19-1 and Table 19-2 give an overview on all registers and their individual bits in the MSCAN memory map. The *register address* results from the addition of *base address* and *address offset*. The *base address* is determined at the MPC5200B MCU level. The *address offset* is defined at the module level.

The MSCAN occupies 64 bytes in the memory space. The base address of the MSCAN module is determined at the MPC5200B MCU level when the MCU is defined. The register decode map is fixed and begins at the first address of the module address offset.

**Table 19-1. MSCAN Register Organization**

| Address Offset | |
|---|---|
| $__00<br>$__15 | CONTROL REGISTERS<br>12 BYTES |
| $__18<br>$__19 | RESERVED<br>2 BYTES |
| $__1C<br>$__1D | ERROR COUNTERS<br>2 BYTES |
| $__20<br>$__3F | IDENTIFIER FILTER<br>16 BYTES |
| $__40<br>$__5F | RECEIVE BUFFER<br>16 BYTES (Window) |
| $__60<br>$__7F | TRANSMIT BUFFER<br>16 BYTES (Window) |

Table 19-1 shows the individual registers associated with the MSCAN and their relative offset from the base address. The detailed register descriptions follow in the order they appear in the register map (see Table 19-2).

**Table 19-2. Module Memory Map**

| Address | Use | Access |
|---|---|---|
| $__00,$__80 | MSCAN Control Register 0 (CANCTL0) | R/W[1] |
| $__01,$__81 | MSCAN Control Register 1 (CANCTL1) | R/W[1] |
| $__04,$__84 | MSCAN Bus Timing Register 0 (CANBTR0) | R/W |
| $__05,$__85 | MSCAN Bus Timing Register 1 (CANBTR1) | R/W |
| $__08,$__88 | MSCAN Receiver Flag Register (CANRFLG) | R/W[1] |
| $__09,$__89 | MSCAN Receiver Interrupt Enable Register (CANRIER) | R/W |
| $__0C,$__8C | MSCAN Transmitter Flag Register (CANTFLG) | R/W[1] |
| $__0D,$__8D | MSCAN Transmitter Interrupt Enable Register (CANTIER) | R/W[1] |
| $__10,$__80 | MSCAN Transmitter Message Abort Control (CANTARQ) | R/W[1] |
| $__11,$__91 | MSCAN Transmitter Message Abort Control (CANTAAK) | R |
| $__14,$__94 | MSCAN Transmit Buffer Selection (CANTBSEL) | R/W[1] |
| $__15,$__95 | MSCAN Identifier Acceptance Control Register (CANIDAC) | R/W[1] |
| $__18 -$__19, $__98 -$__99 | RESERVED | |
| $__1C,$__9C | MSCAN Receive Error Counter Register (CANRXERR) | R |
| $__1D,$__9D | MSCAN Transmit Error Counter Register (CANTXERR) | R |
| $__20,$__A0 | MSCAN Identifier Acceptance Register 0 (CANIDAR0) | R/W |
| $__21,$__A1 | MSCAN Identifier Acceptance Register 1 (CANIDAR1) | R/W |
| $__24,$__A4 | MSCAN Identifier Acceptance Register 2 (CANIDAR2) | R/W |
| $__25,$__A5 | MSCAN Identifier Acceptance Register 3 (CANIDAR3) | R/W |
| $__28,$__A8 | MSCAN Identifier Mask Register 0 (CANIDMR0) | R/W |
| $__29,$__A9 | MSCAN Identifier Mask Register 1 (CANIDMR1) | R/W |
| $__2C,$__AC | MSCAN Identifier Mask Register 2 (CANIDMR2) | R/W |
| $__2D,$__AD | MSCAN Identifier Mask Register 3 (CANIDMR3) | R/W |
| $__30,$__B0 | MSCAN Identifier Acceptance Register 4 (CANIDAR4) | R/W |
| $__31,$__B1 | MSCAN Identifier Acceptance Register 5 (CANIDAR5) | R/W |
| $__34,$__B4 | MSCAN Identifier Acceptance Register 6 (CANIDAR6) | R/W |
| $__35,$__B5 | MSCAN Identifier Acceptance Register 7 (CANIDAR7) | R/W |
| $__38,$__B8 | MSCAN Identifier Mask Register 4 (CANIDMR4) | R/W |
| $__39,$__B9 | MSCAN Identifier Mask Register 5 (CANIDMR5) | R/W |
| $__3C,$__BC | MSCAN Identifier 6 Mask Register 6 (CANIDMR6) | R/W |
| $__3D,$__BD | MSCAN Identifier Mask Register 7 (CANIDMR7) | R/W |
| $__40 -$__5F, $__C0 -$__DF | Foreground Receive Buffer (CANRXFG) | R[2] |
| $__60 -$__7F, $__E0 -$__FF | Foreground Transmit Buffer (CANTXFG) | R[2]/W |

1 Refer to detailed register description for write access restrictions on per bit basis.

2 Reserved bits and unused bits within the TX- & RX-Buffers (CANTXFG, CANRXFG) will be read as “X”, because of RAM based implementation.

## 19.5.2 Register Descriptions

This section describes in detail all the registers and register bits in the MSCAN module. Each description includes a standard register diagram with an associated figure number. Details of register bit and field function follow the register diagrams, in bit order. All bits of all registers in this module are completely synchronous to internal clocks during a register read.

The registers are located at an offset from MBAR of 0x0900 (MSCAN1) and 0x0980 (MSCAN2). Register addresses are relative to this offset.

### 19.5.2.1 MSCAN Control Register 0 (CANCTL0)

Address MBAR + 0x0900/0x980

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | RXFRM | RXACT | CSWAI | SYNCH | TIME | WUPE | SLPRQ | INITRQ |
| W | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Figure 19-3. MSCAN Control Register 0**

The MSCAN Control Register 0, CANCTL0, provides for various control of the MSCAN Module.

**NOTENOTE**

The MSCAN Control Register 0, except the WUPE, INITRQ and SLPRQ bits, is held in the reset state when the Initialization Mode is active (INITRQ = 1 and INITAK = 1). This register is writable again as soon as the Initialization Mode is exited (INITRQ = 0 and INITAK = 0).

Read: Anytime

Write: Anytime when out of Initialization; exceptions are bits RXACT and SYNCH which are read-only and bit RXFRM which is set by the module. A write of ‘1’ to the RXFRM register clears the flag and a write of ‘0’ is ignored.

**Table 19-3. MSCAN Control Register 0 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | RXFRM | Received Frame—flag bit is read and clear only. It is set when a receiver has received a valid message correctly, independently of the filter configuration. Once set, it remains set until cleared by software or reset. Clear by writing 1 to the bit. This bit is not valid in loop-back mode.<br>0 No valid message was received since last clearing this flag<br>1 A valid message was received since last clearing of this flag |
| 1 | RXACT | Receiver Active Status—flag bit indicates MSCAN is receiving a message. The flag is controlled by the receiver front end. This bit is not valid in loop-back mode.<br>0 MSCAN is transmitting or idle<br>1 MSCAN is receiving a message (including when arbitration is lost)<br>**Note:** See the Bosch CAN 2.0A/B protocol specification dated September 1991 for a detailed definition of transmitter and receiver states. |

**Table 19-3. MSCAN Control Register 0 Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 2 | CSWAI | CAN Stops in Wait Mode—enabling this bit allows lower power consumption in wait mode by disabling all clocks at the bus interface to the MSCAN module.<br>0 Module is not affected during WAIT mode<br>1 Module ceases to be clocked during WAIT mode |
| 3 | SYNCH | Synchronized Status—flag bit indicates whether MSCAN is synchronized to the CAN bus and, as such, can participate in the communication process. It is set and cleared by MSCAN.<br>0 MSCAN is not synchronized to the CAN bus<br>1 MSCAN is synchronized to the CAN bus |
| 4 | TIME | Timer Enable—bit activates an internal 16-bit wide free running timer, clocked by the bit-clock. If timer is enabled, a 16-bit time stamp is assigned to each transmitted/received message within the active Tx/Rx buffer. As soon as a message is acknowledged on CAN, the time stamp is written to the highest bytes ($_E, $_F) in the appropriate buffer. The internal timer is reset (all bits set to “0”) when Initialization Mode is active.<br>0 Disable internal MSCAN timer<br>1 Enable internal MSCAN timer |
| 5 | WUPE | WakeUp Enable—bit lets MSCAN restart when being locked in idle state during sleep mode and traffic on CAN is detected.<br>0 WakeUp disabled—MSCAN ignores traffic on CAN<br>1 WakeUp enabled—MSCAN is able to restart |
| 6 | SLPRQ | Sleep Mode Request—bit requests MSCAN enter sleep mode, an internal power saving mode. If a CAN message transfer is occurring when receiving this request, MSCAN waits until end of current message before entering sleep mode. The module indicates entry to Sleep Mode by setting SLPAK=1. MSCAN Control 1 Register (CANCTL1). Sleep mode is active until the CPU clears SLPRQ or, depending on the WUPE bit setting, MSCAN detects CAN bus activity and clears SLPRQ.<br>0 Running—MSCAN functions normally<br>1 Sleep Mode Request—MSCAN locks in idle state |
| 7 | INITRQ | Initialization Mode Request—When the CPU sets this bit, MSCAN skips to initialization mode. Any ongoing transmission or reception is aborted and bus synchronization lost. The module indicates entry to initialization mode by setting INITAK=1 |

### 19.5.2.2 MSCAN Control Register 1 (CANCTL1)

Address MBAR + 0x0901/0x981

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | CANE | CLKSRC | LOOPB | LISTEN | Reserved | Reserved | SLPAK | INITAK |
| W | | | | | | | Reserved | |
| Reset | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |

**Figure 19-4. MSCAN Control Register 1**

The MSCAN Control Register 1 provides for various control and handshake status information of the MSCAN module.

Read: Anytime

Write: Anytime when INITRQ = 1 and INITAK = 1, except CANE which is write once in normal modes and anytime in special modes when the MSCAN is in Initialization Mode (INITRQ = 1 and INITAK = 1).

**Table 19-4. MSCAN Control Register 1**

| Bit | Name | Description |
|---|---|---|
| 0 | CANE | MSCAN Enable<br>0 MSCAN module is disabled<br>1 MSCAN module is enabled |
| 1 | CLKSRC | MSCAN Clock Source—bit defines MSCAN module clock source (only for systems with a system clock generation module.<br>0 MSCAN clock source is the IP bus clock (IP CLK)<br>1 MSCAN clock source is the oscillator clock (SYS_XTAL_IN)<br>**Note:** The two MSCAN modules can have different selected clock sources. |
| 2 | LOOPB | Loop-Back Self-Test Mode—when bit is set, MSCAN does an internal loop-back that can be used for self test operation. Tx bit-stream output feeds back to receiver internally. RxCAN input pin is ignored and TxCAN output goes to recessive state (logic ‘1’). MSCAN behaves as it does normally when transmitting and treats its own transmitted message as a message received from a remote node. In this state, MSCAN ignores bit sent during ACK slot in CAN frame acknowledge field to ensure proper reception of its own message. Both Tx and Rx interrupts are generated. |
| 3 | LISTEN | Listen-Only Mode—bit configures MSCAN as bus monitor. When bit is set, all valid CAN messages with matching ID are received, but no acknowledgement or error frames are sent out. In addition, error counters are frozen. Listen-only mode supports applications that require “hot plugging” or throughput analysis. MSCAN is unable to transmit any messages, when listen-only mode is active.<br>0 Normal operation<br>1 Listen Only Mode activated |
| 4–5 | — | Reserved |

**Table 19-4. MSCAN Control Register 1 (continued)**

| Bit | Name | Description |
|---|---|---|
| 6 | SLPAK | Sleep Mode Acknowledge—flag indicates whether MSCAN module has entered sleep mode. It is used as a handshake flag for SLPRQ sleep mode request. Sleep mode is active when INITRQ=1 and INITAK=1. Depending on the WUPE bit setting, MSCAN clears the flag if it detects bus activity on CAN while in Sleep Mode.<br>0 Running—MSCAN operates normally<br>1 Sleep Mode Active—MSCAN has entered Sleep Mode |
| 7 | INITAK | Initialization Mode Acknowledge—flag indicates whether MSCAN module is in initialization mode. It is used as a handshake flag for the INITRQ initialization mode request. Initialization mode is active when INITRQ=1 and INITAK=1. The registers CANCTL1, CANBTR0, CANBTR1, CANIDAC, CANIDAR0-7, CANIDMR0-7 can only be written by the CPU when the MSCAN is in initialization mode.<br>0 Running – The MSCAN operates normally<br>1 Initialization Mode Active – The MSCAN has entered initialization mode |

### 19.5.2.3 MSCAN Bus Timing Register 0 (CANBTR0)

Address MBAR + 0x0904/0x984

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | SJW[1:0] | | | | BRP[5:0] | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-5. MSCAN Bus Timing Register 0**

The MSCAN Bus Timing Register 0 provides for various bus timing control of the MSCAN module.

Read: Anytime

Write: Anytime in Initialization Mode (INITRQ = 1 and INITAK = 1)

**Table 19-5. MSCAN Bus Timing Register 0 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:1 | SJW[1:0] | Synchronization Jump Width—defines the maximum number of time quanta (Tq) clock cycles a bit can be shortened or lengthened to achieve re-synchronization to data transitions on the bus.<br>00 1 Tq clock cycle<br>01 2 Tq clock cycles<br>10 3 Tq clock cycles<br>11 4 Tq clock cycles |
| 2:7 | BRP[5:0] | Baud Rate Prescaler—bits determine time quanta (Tq) clock used to build up individual bit timing, see Table 19-6. |

**Table 19-6. Baud Rate Prescaler**

| BRP5 | BRP4 | BRP3 | BRP2 | BRP1 | BRP0 | Prescaler Value (P) |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| 0 | 0 | 0 | 0 | 1 | 0 | 3 |
| 0 | 0 | 0 | 0 | 1 | 1 | 4 |
| ..... | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 0 | 63 |
| 1 | 1 | 1 | 1 | 1 | 1 | 64 |

### 19.5.2.4 MSCAN Bus Timing Register 1 (CANBTR1)

Address MBAR + 0x0905/0x985

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | SAMP | TSEG[22:20] | | | TSEG[13:10] | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-6. MSCAN Bus Timing Register 1**

The MSCAN Bus Timing Register 1 provides for various bus timing control of the MSCAN module.

Read: Anytime

Write: Anytime in Initialization Mode (INITRQ = 1 and INITAK = 1)

**Table 19-7. MSCAN Bus Timing Register 1 Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | SAMP | Sampling—bit determines number of serial bus samples taken per bit-time. If set, three samples per bit are taken; the regular one (sample point) and two preceding samples using a majority rule. For higher bit-rates, it is recommended that SAMP be cleared, which means only one sample is taken per bit.<br>0 One sample per bit<br>1 Three samples per bit |
| 1:3 | TSEG[22:20] | Time Segment 2—time segments within the bit-time, fix the number of clock cycles per bit-time and the location of the sample point. Time segment 2 (TSEG2) values are programmable as shown in Table 19-9. |
| 4:7 | TSEG[13:10] | Time Segment 1—time segments within the bit-time, fix the number of clock cycles per bit-time and the location of the sample point. Time segment 1 (TSEG1) values are programmable as shown in Table 19-8. |

Bit-time, as shown below, is determined by:

- Oscillator frequency
- Baud rate prescaler
- Number of time quanta (Tq) clock cycles per bit

Table 19-8 and Table 19-9 give time segment values.

$$\text{Bit Time} = \frac{(\text{Prescaler value})}{f_{CANCLK}} \bullet (\text{Number of Time Quanta})$$

**Table 19-8. Time Segment 1 Values**

| TSEG13 | TSEG12 | TSEG11 | TSEG10 | Time segment 1 |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 Tq clock cycle (a) |
| 0 | 0 | 0 | 1 | 2 Tq clock cycles (1) |
| 0 | 0 | 1 | 0 | 3 Tq clock cycles (1) |
| 0 | 0 | 1 | 1 | 4 Tq clock cycles |
| ..... | | | | |
| 1 | 1 | 1 | 0 | 15 Tq clock cycles |
| 1 | 1 | 1 | 1 | 16 Tq clock cycles |

**Table 19-9. Time Segment 2 Values**

| TSEG22 | TSEG21 | TSEG20 | Time segment 2 |
|---|---|---|---|
| 0 | 0 | 0 | 1 Tq clock cycle (a) |
| 0 | 0 | 1 | 2 Tq clock cycles |
| ..... | | | |
| 1 | 1 | 0 | 7 Tq clock cycles |
| 1 | 1 | 1 | 8 Tq clock cycles |

### 19.5.2.5 MSCAN Receiver Flag Register (CANRFLG)

Address MBAR + 0x0908/0x988

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | WUPIF | CSCIF | RSTAT[1:0] | | TSTAT[1:0] | | OVRIF | RXF |
| W | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-7. MSCAN Receiver Flag Register**

**NOTE**

This register is held in the reset state when the initialization mode is active (INITRQ = 1 and INITAK = 1). This register is writable again as soon as the initialization mode is exited (INITRQ = 0 and INITAK = 0).

A flag can only be cleared when the condition which caused the setting is no longer valid and can only be cleared by software (writing a “1” to the corresponding bit position). Every flag has an associated interrupt enable bit in the MSCAN Receive Interrupt Enable Register.

Read: Anytime

Write: Anytime when out of initialization mode, except RSTAT(1:0) & TSTAT(1:0) flags which are read only; write of “1” clears flag; write of “0” ignored.

**Table 19-10. MSCAN Receiver Flag Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | WUPIF | WakeUp Interrupt Flag—If MSCAN detects bus activity while in sleep mode and WUPE=1 in CANTCTL0, it sets the WUPIF flag. If not masked, a WakeUp interrupt is pending while this flag is set.<br>0 No WakeUp activity observed while in Sleep Mode.<br>1 MSCAN detected bus activity and requested WakeUp. |
| 1 | CSCIF | CAN Status Change Interrupt Flag—flag is set when MSCAN changes its current bus status due to actual value of Tx error counter (TEC) and Rx error counter (REC). An additional 4-bit (RSTAT[1:0], TSTAT[1:0]) status register, split into separate sections for TEC/REC, notifies system of actual bus status.<br>If not masked, an error interrupt is pending while this flag is set. CSCIF provides a blocking interrupt. That guarantees the Rx/Tx status bits (RSTAT/TSTAT) are updated only when no CAN Status Change interrupt is pending.<br>If TECs/RECs change their current value after CSCIF is asserted and therefore cause an additional state change in RSTAT/TSTAT bits, these bits keep their old state bits until the current CSCIF interrupt is again cleared.<br>0 No change in bus status occurred since last interrupt<br>1 MSCAN changed current bus status. |

**Table 19-10. MSCAN Receiver Flag Register Field Descriptions (continued)**

| Bit | Name | Description |
|---|---|---|
| 2:3 | RSTAT[1:0] | Receiver Status bits—values of the error counters control the actual bus status of the MSCAN. As soon as the status change interrupt flag (CSCIF) is set these bits indicate the appropriate receiver related bus status of the MSCAN. The coding for the bits RSTAT1, RSTAT0 is:<br>00 RxOK: 0 ≤ Receive Error Counter ≤ 96<br>01 RxWRN: 96 < Receive Error Counter ≤ 127<br>10 RxERR: 127 < Receive Error Counter<br>11 BusOff: Transmit Error Counter > 255<br>**Note:** Redundant Information for the most critical bus status which is CAN Bus-Off. This only occurs if the Tx Error Counter exceeds a number of 255 errors. CAN Bus-Off affects the receiver state. As soon as the transmitter leaves its Bus-Off state the receiver state skips to RxOK too. Refer also to TSTAT[1:0] coding. |
| 4:5 | TSTAT[1:0] | Transmitter Status bits—values of the error counters control the actual bus status of the MSCAN. As soon as the status change interrupt flag (CSCIF) is set these bits indicate the appropriate transmitter related bus status of the MSCAN. The coding for the bits TSTAT1, TSTAT0 is:<br>00 TxOK: 0 ≤ Transmit Error Counter ≤ 96<br>01 TxWRN: 96 < Transmit Error Counter ≤ 127<br>10 TxERR: 127 < Transmit Error Counter ≤ 255<br>11 BusOff: Transmit Error Counter > 255 |
| 6 | OVRIF | Overrun Interrupt Flag—flag is set when a data overrun condition occurs. If not masked, an Error interrupt is pending while this flag is set.<br>0 No data overrun condition.<br>1 data overrun detected. |
| 7 | RXF | Receive Buffer Full—flag is set by MSCAN when a new message is shifted into RX FIFO. Flag indicates whether the shifted buffer is loaded with a correctly received message (matching identifier, matching cyclic redundancy code (CRC) and no other errors detected). After CPU reads message from RxFG buffer in Rx FIFO, RxF flag must be cleared to release the buffer.<br>A set RxF flag prohibits shifting of next FIFO entry into foreground buffer (RxFG). If not masked, RX interrupt is pending while this flag is set.<br>To ensure data integrity, do not read the Rx buffer registers while RxF flag is cleared. For MCUs with dual CPUs, reading Rx buffer registers while RxF flag is cleared may result in a CPU fault condition.<br>0 No new message available within the RxFG.<br>1 The receiver FIFO is not empty. A new message is available in the RxFG.<br>**Note:** To ensure data integrity, do not read the receive buffer registers while the RXF flag is cleared.For MCUs with dual CPUs, reading the receive buffer registers while the RXF flag is cleared may result in a CPU fault condition. |

**Note:**

1. Every flag has an associated interrupt enable bit in the CANRIER register. A flag can only be cleared:
   - When the condition that caused the setting is no longer valid.
   - By software writing 1 to the corresponding bit position.

### 19.5.2.6 MSCAN Receiver Interrupt Enable Register (CANRIER)

Address MBAR + 0x0909/0x989

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | WUPIE | CSCIE | RSTATE[1:0] | | TSTATE[1:0] | | OVRIE | RXFIE |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-8. MSCAN Receiver Interrupt Enable Register**

**Table 19-11. MSCAN Receiver Interrupt Enable Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0 | WUPIE | WakeUp Interrupt Enable<br>0 No interrupt request is generated from this event.<br>1 A WakeUP event causes a WakeUp interrupt request. |
| 1 | CSCIE | CAN Status Change Interrupt Enable<br>0 No interrupt request is generated from this event<br>1 A CAN Status Change event causes an error interrupt request |
| 2:3 | RSTATE[1:0] | Receiver Status Change Enable—bits control sensitivity level in which Rx state changes cause CSCIF interrupts. Independent of the chosen sensitivity level, RSTATE flags still indicate the actual Rx state and are only updated if no CSCIF interrupt is pending.<br>00 Do not generate CSCIF interrupt caused by Rx state changes.<br>01 Generate CSCIF interrupt only if receiver enters or leaves “BusOff” state. Discard other Rx state changes for generating CSCIF interrupt.<br>10 Generate CSCIF interrupt only if receiver enters or leaves “RxErr” or “BusOff” state. Discard other Rx state changes for generating CSCIF interrupt.<br>11 Generate CSCIF interrupt on all Rx state changes. |
| 4:5 | TSTATE[1:0] | Transmitter Status Change Enable—bits control sensitivity level in which Tx state changes cause CSCIF interrupts. Independent of the chosen sensitivity level, TSTATE flags still indicate the actual Tx state and are only updated if no CSCIF interrupt is pending.<br>00 Do not generate CSCIF interrupt caused by Tx state changes.<br>01 Generate CSCIF interrupt only if transmitter enters or leaves “BusOff” state. Discard other Tx state changes for generating CSCIF interrupt.<br>10 Generate CSCIF interrupt only if transmitter enters or leaves “TxErr” or “BusOff” state. Discard other Tx state changes for generating CSCIF interrupt.<br>11 Generate CSCIF interrupt on all Tx state changes. |
| 6 | OVRIE | Overrun Interrupt Enable<br>0 No interrupt request is generated from this event.<br>1 An overrun event causes an overrun interrupt request |
| 7 | RXFIE | Receiver Full Interrupt Enable<br>0 No interrupt request is generated from this event<br>1 Rx buffer full (successful message reception) event causes Rx full interrupt request |

**NOTE**

The MSCAN Receive Interrupt Enable Register is held in reset state when the initialization mode is active (INITRQ = 1 and INITAK = 1). This register is writable again as soon as the initialization mode is exited (INITRQ = 0 and INITAK = 0).

### 19.5.2.7 MSCAN Transmitter Flag Register (CANTFLG)

Address MBAR + 0x090C/0x98C

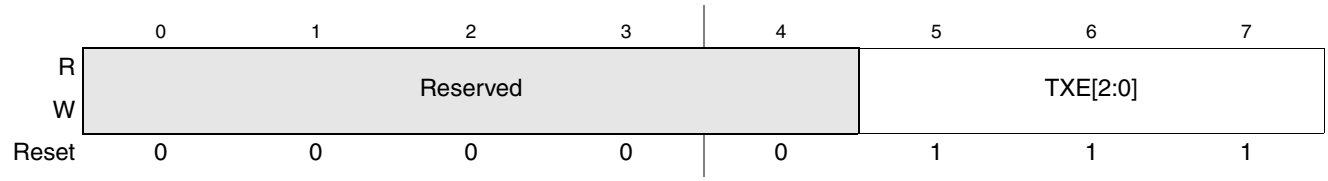



**Figure 19-9. MSCAN Transmitter Flag Register**

**Table 19-12. MSCAN Transmitter Flag Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:4 | — | Reserved |
| 5:7 | TXE[2:0] | Transmitter Buffer Empty—flag indicates the associated Tx message buffer is empty, and thus not scheduled for transmission. CPU must clear the flag after a message is set up in the Tx buffer and is due for transmission. MSCAN sets flag after message is successfully sent. Flag is also set by MSCAN when Tx request is successfully aborted due to a pending abort request. If not masked, a Tx interrupt is pending while this flag is set.<br>Clearing a TxEx flag also clears the corresponding ABTAKx. When a TxEx flag is set, the corresponding ABTRQx bit is cleared. When listen-mode is active TxEx flags cannot be cleared and no transmission is started.<br>0 Associated message buffer full (loaded with message due for Tx)<br>1 Associated message buffer empty (not scheduled) |

**NOTE**

This register is held in the reset state when the initialization mode is active (INITRQ = 1 and INITAK = 1). This register is writable again as soon as the initialization mode is exited (INITRQ = 0 and INITAK = 0).

To insure data integrity, do not write to Tx buffer registers while the TXE flag is cleared

Read: Anytime

Write: Anytime for TXEx flags when not in Initialization Mode; write of “1” clears flag, write of ‘0’ is ignored.

### 19.5.2.8 MSCAN Transmitter Interrupt Enable Register (CANTIER)

Address MBAR + 0x090D/0x98D

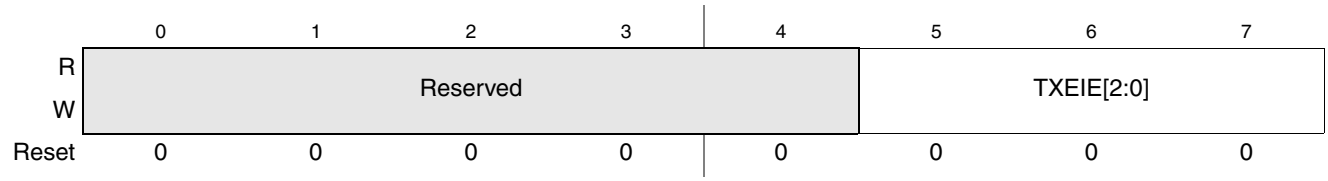



**Figure 19-10. MSCAN Transmitter Interrupt Enable Register**

**Table 19-13. MSCAN Transmitter Interrupt Enable Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:4 | — | Reserved |
| 5:7 | TXEIE[2:0] | Transmitter Empty Interrupt Enable<br>0 No interrupt request is generated from this event.<br>1 Transmitter empty (Tx buffer available) event causes Tx empty interrupt request. |

**NOTE**

This register is held in the reset state when the initialization mode is active (INITRQ = 1 and INITAK = 1). This register is writable again as soon as the initialization mode is exited (INITRQ = 0 and INITAK = 0).

Read: Anytime

Write: Anytime when not in Initialization Mode.

### 19.5.2.9 MSCAN Transmitter Message Abort Request (CANTARQ)

Address MBAR + 0x0910/0x990

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | ABTRQ[2:0] | | |
| W | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-11. MSCAN Transmitter Message Abort Request Register**

**Table 19-14. MSCAN Transmitter Message Abort Request Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:4 | — | Reserved |
| 5:7 | ABTRQ[2:0] | Abort Request—CPU sets bit to request a scheduled message buffer (TxEx=0) be aborted. MSCAN grants request if message has not already started transmission, or if transmission is not successful (lost arbitration or error). When message is aborted, the associated TxE and abort acknowledge flags (ABTAK) are set and a Tx interrupt occurs if enabled. The CPU cannot reset ABTRQx. ABTRQx is reset whenever the associated TxE flag is set.<br>0 No abort request<br>1 Abort request pending |

**NOTE**

This register is held in the reset state when the initialization mode is active (INITRQ = 1 and INITAK = 1). This register is writable again as soon as the initialization mode is exited (INITRQ = 0 and INITAK = 0).

Read: Anytime

Write: Anytime when not in Initialization Mode; write of “1” clears flag, write of ‘0’ is ignored.

**NOTE**

Software must not clear one or more bits of TXE Flag and simultaneously set the respective ABTRQ bit(s).

### 19.5.2.10 MSCAN Transmitter Message Abort Acknowledge (CANTAAK)

Address MBAR + 0x0911/0x991

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | ABTAK[2:0] | | |
| W | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Note:** This register is held in the reset state when the initialization mode is active (INITRQ = 1 and INITAK = 1).

**Figure 19-12. MSCAN Transmitter Message Abort Acknowledgement Register**

READ: Anytime

WRITE: Not writable at any time

**Table 19-15. MSCAN Transmitter Message Abort Acknowledgement Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:4 | — | Reserved |
| 5:7 | ABTAK[2:0] | Abort Acknowledge—flag acknowledges a message was aborted due to a pending CPU abort request. After a specific message buffer is flagged empty, application software can use this flag to identify whether message was successfully aborted or was sent. Flag is cleared whenever the corresponding TxE flag is cleared.<br>0 Message not aborted<br>1 Message aborted |

### 19.5.2.11 MSCAN Transmit Buffer Selection (CANTBSEL)

Address MBAR + 0x0914/0x994

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | Reserved | | | | | TX[2:0] | | |
| W | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Note:** This register is held in the reset state when the initialization mode is active (INITRQ = 1 and INITAK = 1). This register is writable again as soon as the initialization mode is exited (INITRQ = 0 and INITAK = 0)..

**Figure 19-13. MSCAN Transmit Buffer Selection Register**

**Table 19-16. MSCAN Transmit Buffer Selection Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:4 | — | Reserved |
| 5:7 | TX[2:0] | Transmit Buffer Select—lowest numbered bit places respective Tx buffer in CANTxFG register space (e.g., Tx1=1 and Tx0=1 selects Tx buffer Tx0, Tx1=1 and Tx0=0 selects Tx buffer Tx1)<br>0 Associated message buffer deselected<br>1 Associated message buffer selected, if lowest numbered bit |

Read: Find the lowest ordered bit set to ‘1’, all other bits will be read as ‘0’

Write: Anytime when not in Initialization Mode

### 19.5.2.12 MSCAN ID Acceptance Control Register (CANIDAC)

Address MBAR + 0x0915/0x995

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | Reserved | | IDAM[1:0] | | Reserved | IDHIT[2:0] | | |
| W | | | | | | Reserved | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-14. MSCAN ID Acceptance Control Register**

Read: Anytime

Write: Anytime in Initialization Mode (INITRQ = 1 and INITAK =1)

**Table 19-17. MSCAN ID Acceptance Control Register Field Descriptons**

| Bit | Name | Description |
|---|---|---|
| 0:1 | — | Reserved |
| 2:3 | IDAM[1:0] | Identifier Acceptance Mode—CPU sets these flags to define the identifier acceptance filter organization. In filter closed mode, no message is accepted such that the foreground buffer is never reloaded. See Table 19-19. |
| 4 | — | Reserved |
| 5:7 | IDHIT[2:0] | Identifier Acceptance Hit Indicator—MSCAN sets these flags to indicate an identifier acceptance hit. See Table 19-18. |

**Table 19-18. Identifier Acceptance Hit Indication**

| IDHIT2 | IDHIT1 | IDHIT0 | Identifier Acceptance Hit |
|---|---|---|---|
| 0 | 0 | 0 | Filter 0 Hit |
| 0 | 0 | 1 | Filter 1 Hit |
| 0 | 1 | 0 | Filter 2 Hit |
| 0 | 1 | 1 | Filter 3 Hit |
| 1 | 0 | 0 | Filter 4 Hit |
| 1 | 0 | 1 | Filter 5 Hit |
| 1 | 1 | 0 | Filter 6 Hit |
| 1 | 1 | 1 | Filter 7 Hit |

**Table 19-19. Identifier Acceptance Mode Settings**

| IDAM1 | IDAM0 | Identifier Acceptance Mode |
|---|---|---|
| 0 | 0 | Two 32-bit Acceptance Filters |
| 0 | 1 | Four 16-bit Acceptance Filters |
| 1 | 0 | Eight 8-bit Acceptance Filters |
| 1 | 1 | Filter Closed |

### 19.5.2.13 MSCAN Receive Error Counter Register (CANRXERR)

Address MBAR + 0x091C/0x99C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | RxERR[7:0] | | | | | | | |
| W | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-15. MSCAN Receive Error Counter Register**

Read: Only when in Sleep Mode (SLPRQ = 1 and SLPAK = 1) or Initialization Mode (INITRQ = 1 and INITAK =1).

Write: Unimplemented

**Table 19-20. MSCAN Receive Error Counter Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | RxERR[7:0] | This register reflects the status of the MSCAN receive error counter. |

**NOTE**

Reading this register when in any other mode other than sleep or Initialization may return an incorrect value.

Writing to these registers when in special modes can alter the MSCAN functionality.

### 19.5.2.14 MSCAN Transmit Error Counter Register (CANTXERR)

Address MBAR + 0x091D/0x99D

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | TxERR[7:0][7:0] | | | | | | | |
| W | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-16. MSCAN Transmit Error Counter Register**

**NOTE**

This register reflects the status of the MSCAN transmit error counter.

Read: Only when in Sleep Mode (SLPRQ = 1 and SLPAK = 1) or Initialization Mode (INITRQ = 1 and INITAK =1).

Write: Unimplemented

**Table 19-21. MSCAN Transmit Error Counter Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | TxERR[7:0] | This register reflects the status of the MSCAN transmit error counter. |

**NOTE**

Reading this register when in any other mode other than sleep or Initialization may return an incorrect value.

Writing to these registers when in special modes can alter the MSCAN functionality.

### 19.5.2.15 MSCAN ID Acceptance Registers (CANIDAR0–CANIDAR7)

Address MBAR + 0x0920/0x9A0 — CANIDAR0

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AC7 | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Address MBAR + 0x0921/0x9A1 — CANIDAR1

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AC7 | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Address MBAR + 0x0924/0x9A4 — CANIDAR2

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AC7 | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Address MBAR + 0x0925/0x9A5 — CANIDAR3

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AC7 | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-17. MSCAN ID Acceptance Registers (CANIDAR0–CANIDAR3)**

Address MBAR + 0x0930/0x9b0 — CANIDAR4

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AC7 | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Address MBAR + 0x0931/0x9B1 — CANIDAR5

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AC7 | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Address MBAR + 0x0934/0x9B4 — CANIDAR6

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AC7 | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Address MBAR + 0x0935/0x9B5 — CANIDAR7

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AC7 | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-18. MSCAN ID Acceptance Registers (CANIDAR4–CANIDAR7)**

**Table 19-22. MSCAN ID Acceptance Registers Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | AC[7:0] | Acceptance Code—bits comprise a user defined sequence with which corresponding bits of the related identifier register (IDRn) of the receive message buffer are compared. Result of this comparison is then masked with the corresponding identifier mask register. |

Read: Anytime

Write: Anytime in initialization mode (INITRQ + 1 and INITAK = 1).

On reception, each message is written into the background receive buffer. The CPU is only signalled to read the message if it passes the criteria in the identifier acceptance and identifier mask registers (accepted); otherwise, the message is overwritten by the next message (dropped).

The acceptance registers of the MSCAN are applied on the IDR0 to IDR3 registers of incoming messages in a bit-by-bit manner.

For extended identifiers, all four acceptance and mask registers are applied. For standard identifiers, only the first two (CANIDAR0/1 and CANIDMR0/1) are applied.

### 19.5.2.16 MSCAN ID Mask Register (CANIDMR0–CANIDMR7)

Address MBAR + 0x0920/0x9A0 — CANIDMR0

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AM7 | AM6 | AM5 | AM4 | AM3 | AM2 | AM1 | AM0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Address MBAR + 0x0921/0x9A1 — CANIDMR1

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AM7 | AM6 | AM5 | AM4 | AM3 | AM2 | AM1 | AM0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Address MBAR + 0x0924/0x9A4 — CANIDMR2

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AM7 | AM6 | AM5 | AM4 | AM3 | AM2 | AM1 | AM0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Address MBAR + 0x0925/0x9A5 — CANIDMR3

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AM7 | AM6 | AM5 | AM4 | AM3 | AM2 | AM1 | AM0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-19. MSCAN ID Mask Registers (CANIDMR0–CANIDMR3)**

Address MBAR + 0x0930/0x9b0 — CANIDMR4

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AM7 | AM6 | AM5 | AM4 | AM3 | AM2 | AM1 | AM0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Address MBAR + 0x0931/0x9B1 — CANIDMR5

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AM7 | AM6 | AM5 | AM4 | AM3 | AM2 | AM1 | AM0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Address MBAR + 0x0934/0x9B4 — CANIDMR6

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AM7 | AM6 | AM5 | AM4 | AM3 | AM2 | AM1 | AM0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Address MBAR + 0x0935/0x9B5 — CANIDMR7

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | AM7 | AM6 | AM5 | AM4 | AM3 | AM2 | AM1 | AM0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-20. MSCAN ID Mask Registers (CANIDMR4–CANIDMR7)**

Read: Anytime

Write: Anytime in initialization mode (INITRQ + 1 and INITAK = 1).

**Table 19-23. MSCAN ID Mask Registers Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | AM[7:0] | Acceptance Mask bits—If a particular bit in this register is cleared, this indicates the corresponding bit in the identifier acceptance register must be the same as its identifier bit before a match is detected. The message is accepted if all such bits match. If a bit is set, it indicates the state of the corresponding bit in the identifier acceptance register does not affect whether or not message is accepted.<br>0 Match corresponding acceptance code register and identifier bits<br>1 Ignore corresponding acceptance code register bit |

The identifier mask register specifies which of the corresponding bits in the identifier acceptance register are relevant for acceptance filtering.

- To receive standard identifiers in 32-bit filter mode, the last three bits (AM[0:2]) in the following mask registers must be programmed as don't care:
  - CANIDMR1
  - CANIDMR5

- To receive standard identifiers in 16-bit filter mode, the last three bits (AM[0:2]) in the following mask registers must be programmed as don't care:
  - CANIDMR1
  - CANIDMR3
  - CANIDMR5
  - CANIDMR7

## 19.6 Programmer's Model of Message Storage

The following section details the organization of the receive and transmit message buffers and the associated control registers. For reasons of programmer interface simplification, the receive and transmit message buffers have the same outline. Each message buffer allocates 16 bytes in the memory map containing a 13 byte data structure. An additional Transmit Buffer Priority Register (TBPR) is defined for the transmit buffers. Within the last two bytes of this memory map the MSCAN stores a special 16-bit time stamp, which is sampled from an internal timer after successful transmission or reception of a message. This feature is only available for transmit and receiver buffers, if the TIME bit is set (Section 19.5.2.1, "MSCAN Control Register 0 (CANCTL0)"). The Time Stamp register is written by the MSCAN. The CPU can only read these registers.

**Table 19-24. Message Buffer Organization**

| Address | Register Name |
|---|---|
| $__00, $__80 | Identifier Register 0 |
| $__01, $__81 | Identifier Register 1 |
| $__04, $__844 | Identifier Register 2 |
| $__05, $__85 | Identifier Register 3 |
| $__08, $__88 | Data Segment Register 0 |
| $__09, $__89 | Data Segment Register 1 |
| $__0C, $__8C | Data Segment Register 2 |
| $__0D, $__8D | Data Segment Register 3 |
| $__10, $__90 | Data Segment Register 4 |
| $__11, $__91 | Data Segment Register 5 |
| $__14, $__94 | Data Segment Register 6 |
| $__15, $__95 | Data Segment Register 7 |
| $__18, $__98 | Data Length Register |
| $__19, $__99 | Transmit Buffer Priority Register[1] |
| $__1C, $__9C | Time Stamp Register (High Byte)[2] |
| $__1D, $__9D | Time Stamp Register (Low Byte)[3] |

1 Not Applicable for Receive Buffers
2 Read-Only for CPU
3 Read-Only for CPU

Figure 19-21 shows the common 13 byte data structure of receive and transmit buffers for extended identifiers. The mapping of standard identifiers into the IDR registers is shown in Figure 19-22. All bits of the receive and transmit buffers are ‘x’ out of reset because of RAM based implementation[1].All reserved or unused bits of the receive and transmit buffers are always read ‘x’.

| Register | | Bit 7 | 6 | 5 | 4 | 3 | 2 | 1 | Bit 0 | ADDR |
|---|---|---|---|---|---|---|---|---|---|---|
| IDR0 | Read:<br>Write: | ID28 | ID27 | ID26 | ID25 | ID24 | ID23 | ID22 | ID21 | $__00 |
| IDR1 | Read:<br>Write: | ID20 | ID19 | ID18 | SRR (=1) | IDE (=1) | ID17 | ID16 | ID15 | $__01 |
| IDR2 | Read:<br>Write: | ID14 | ID13 | ID12 | ID11 | ID10 | ID9 | ID8 | ID7 | $__04 |
| IDR3 | Read:<br>Write: | ID6 | ID5 | ID4 | ID3 | ID2 | ID1 | ID0 | RTR | $__05 |
| DSR0 | Read:<br>Write: | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | $__08 |
| DSR1 | Read:<br>Write: | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | $__09 |
| DSR2 | Read:<br>Write: | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | $__0C |
| DSR3 | Read:<br>Write: | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | $__0D |
| DSR4 | Read:<br>Write: | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | $__10 |
| DSR5 | Read:<br>Write: | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | $__11 |
| DSR6 | Read:<br>Write: | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | $__14 |
| DSR7 | Read:<br>Write: | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | $__15 |
| DLR | Read:<br>Write: | | | | | DLC3 | DLC2 | DLC1 | DLC0 | $__18 |

= Unused — Unused bits are always read ‘x’

**Figure 19-21. Receive / Transmit Message Buffer Extended Identifier**

1. Exception: The Transmit Priority Registers are “0” out of reset

Read: anytime for transmit buffers; only when RXF flag is set for receive buffers (see Section 19.5.2.5, “MSCAN Receiver Flag Register (CANRFLG)”).

Write: anytime for transmit buffers when TXEx flag is set (see Section 19.5.2.7, “MSCAN Transmitter Flag Register (CANTFLG)”) and the corresponding transmit buffer is selected in CANTBSEL (see Section 19.5.2.11, “MSCAN Transmit Buffer Selection (CANTBSEL)”); unimplemented for receive buffers

Reset: $xx because of RAM based implementation

| Register | | Bit 7 | 6 | 5 | 4 | 3 | 2 | 1 | Bit 0 | ADDR |
|---|---|---|---|---|---|---|---|---|---|---|
| IDR0 | Read:<br>Write: | ID10 | ID9 | ID8 | ID7 | ID6 | ID5 | ID4 | ID3 | $__x0 |
| IDR1 | Read:<br>Write: | ID2 | ID1 | ID0 | RTR | IDE (=0) | | | | $__x1 |
| IDR2 | Read:<br>Write: | | | | | | | | | $__x4 |
| IDR3 | Read:<br>Write: | | | | | | | | | $__x5 |

= Unused — Unused bits are always read ‘x’

**Figure 19-22. Standard Identifier Mapping**

## 19.6.1 Identifier Registers (IDR0–IDR3)

The identifier registers for an extended format identifier consist of a total of 32 bits; ID28 - ID0, SRR, IDE, and RTR bits. The identifier registers for a standard format identifier consist of a total of 13 bits; ID10 - ID0, RTR, and IDE bits.

ID28–ID0 — Extended format identifier

The identifiers consist of 29 bits (ID28 - ID0) for the extended format. ID28 is the most significant bit and is transmitted first on the bus during the arbitration procedure. The priority of an identifier is defined to be highest for the smallest binary number.

ID10–ID0 — Standard format identifier

The identifiers consist of 11 bits (ID10 – ID0) for the standard format. ID10 is the most significant bit and is transmitted first on the bus during the arbitration procedure. The priority of an identifier is defined to be highest for the smallest binary number.

SRR — Substitute remote request

This fixed recessive bit is used only in extended format. It must be set to 1 by the user for transmission buffers and is stored as received on the CAN bus for receive buffers.

IDE — ID Extended

This flag indicates whether the extended or standard identifier format is applied in this buffer. In the case of a receive buffer, the flag is set as received and indicates to the CPU how to process the buffer identifier registers. In the case of a transmit buffer, the flag indicates to the MSCAN what type of identifier to send.

1 = Extended format (29 bit)

0 = Standard format (11 bit)

RTR — Remote Transmission Request

This flag reflects the status of the Remote Transmission Request bit in the CAN frame. In the case of a receive buffer, it indicates the status of the received frame and supports the transmission of an answering frame in software. In the case of a transmit buffer, this flag defines the setting of the RTR bit to be sent.

1 = Remote frame

0 = Data frame

## 19.6.2 Data Segment Registers (DSR0–DSR7)

The eight data segment registers, each with bits DB7-DB0, contain the data to be transmitted or received. The number of bytes to be transmitted or received is determined by the data length code in the corresponding DLR register.

DB7–DB0 — Data Bits 7-0

### 19.6.2.1 Data Length Register (DLR)

This register keeps the data length field of the CAN frame.

DLC3–DLC0 — Data Length Code bits

The data length code contains the number of bytes (data byte count) of the respective message. During the transmission of a remote frame, the data length code is transmitted as programmed while the number of transmitted data bytes is always 0. The data byte count ranges from 0 to 8 for a data frame. Table 19-25 shows the effect of setting the DLC bits.

**Table 19-25. Data Length Codes**

| Data Length Code | | | | Data Byte Count |
|---|---|---|---|---|
| DLC3 | DLC2 | DLC1 | DLC0 | |
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 0 | 2 |
| 0 | 0 | 1 | 1 | 3 |
| 0 | 1 | 0 | 0 | 4 |
| 0 | 1 | 0 | 1 | 5 |
| 0 | 1 | 1 | 0 | 6 |
| 0 | 1 | 1 | 1 | 7 |
| 1 | 0 | 0 | 0 | 8 |

### 19.6.2.2 MSCAN Transmit Buffer Priority Register (TBPR)

Address MBAR + 0x0979/0x9F9

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | PRIO7 | PRIO6 | PRIO5 | PRIO4 | PRIO3 | PRIO2 | PRIO1 | PRIO0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-23. MSCAN Transmit Buffer Priority Register**

**Table 19-26. MSCAN Transmit Buffer Priority Register Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | PRIO[7:0] | Register defines local priority of associated message buffer. Local priority is used for MSCAN internal prioritization process and is defined to be highest for the smallest binary number. MSCAN implements the following internal prioritization mechanism:<br>• All transmission buffers with a cleared TXEx flag participate in prioritization immediately before start of frame (SOF) is sent.<br>• Transmission buffer with lowest local priority field wins prioritization.<br>• If more than one buffer has the same lowest priority, message buffer with lower index number wins. |

### 19.6.2.3 MSCAN Time Stamp Register High (TSRH)

Address MBAR + 0x097C/0x9FC

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | TSR15 | TSR14 | TSR13 | TSR12 | TSR11 | TSR10 | TSR9 | TSR8 |
| W | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-24. MSCAN Time Stamp Register (High Byte)**

Read: Anytime

Write: Unimplemented

**Table 19-27. MSCAN Time Stamp Register (High Byte) Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | TSR[15:8] | If TIME bit is enabled, MSCAN writes a special time stamp to respective registers in active Tx or Rx buffer as soon as a message is acknowledged on the CAN bus. Time stamp is written on bit sample point for recessive bit of ACK delimiter in CAN frame. If Tx, CPU can only read time stamp after respective Tx buffer is flagged empty.<br>Timer value, used for stamping, is taken from a free running internal CAN bit-clock. Timer overrun is not indicated by MSCAN. Timer is reset (all bits set to 0) during initialization mode. CPU can only read time stamp registers. |

### 19.6.2.4 MSCAN Time Stamp Register Low (TSRL)

Address MBAR + 0x097D/0x9FD

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | TSR7 | TSR6 | TSR5 | TSR4 | TSR3 | TSR2 | TSR1 | TSR0 |
| W | Reserved | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 19-25. MSCAN Time Stamp Register (Low Byte)**

Read: Anytime

Write: Unimplemented

**Table 19-28. MSCAN Time Stamp Register (Low Byte) Field Descriptions**

| Bit | Name | Description |
|---|---|---|
| 0:7 | TSR[7:0] | If TIME bit is enabled, MSCAN writes a special time stamp to respective registers in active Tx or Rx buffer as soon as message is acknowledged on CAN bus. Time stamp is written on bit sample point for recessive bit of ACK delimiter in CAN frame. If Tx, CPU can only read time stamp after respective Tx buffer is flagged empty.<br>Timer value, used for stamping, is taken from a free running internal CAN bit-clock. Timer overrun is not indicated by MSCAN. Timer is reset (all bits set to 0) during initialization mode. CPU can only read time stamp registers. |

## 19.7 Functional Description

### 19.7.1 General

This section provides a complete functional description of the MSCAN. It describes each of the features and modes listed in the introduction.

## 19.7.2 Message Storage

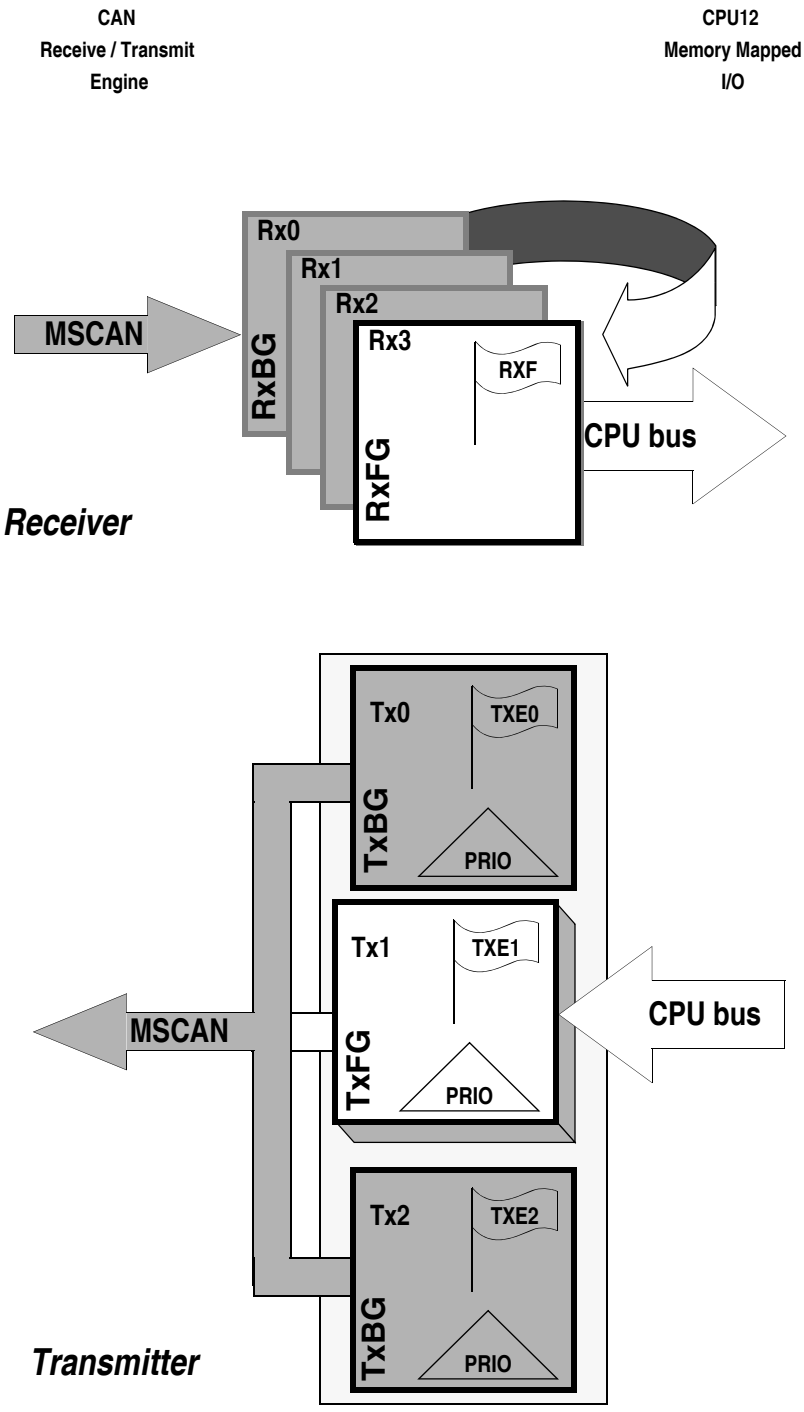



**Figure 19-26. User Model for Message Buffer Organization**

MSCAN facilitates a sophisticated message storage system which addresses the requirements of a broad range of network applications.

### 19.7.2.1 Message Transmit Background

Modern application layer software is built upon two fundamental assumptions:

- Any CAN node is able to send out a stream of scheduled messages without releasing the bus between the two messages. Such nodes arbitrate for the bus immediately after sending the previous message and only release the bus in case of lost arbitration.
- The internal message queue within any CAN node is organized such that the highest priority message is sent out first, if more than one message is ready to be sent.

The above behavior cannot be achieved with a single transmit buffer. That buffer must be reloaded right after the previous message is sent. This loading process lasts a finite amount of time and has to be completed within the Inter-Frame Sequence (IFS)[1] to be able to send an uninterrupted stream of messages. Even if this is feasible for limited CAN bus speeds, it requires that the CPU react with short latencies to the transmit interrupt.

A double buffer scheme de-couples the reloading of the transmit buffer from the actual message sending and, as such, reduces the reactiveness requirements on the CPU. Problems can arise if the sending of a message is finished while the CPU re-loads the second buffer. No buffer would then be ready for transmission and the bus would be released.

At least three transmit buffers are required to meet the first of the above requirements under all circumstances. The MSCAN has three transmit buffers.

The second requirement calls for some sort of internal prioritization which the MSCAN implements with the “local priority” concept described in Section 19.7.2.2, “Transmit Structures”.

### 19.7.2.2 Transmit Structures

The MSCAN has a triple transmit buffer scheme which allows multiple messages to be set up in advance and achieve an optimized real-time performance. The three buffers are arranged as shown in Figure 19-26.

All three buffers have a 13 byte data structure similar to the outline of the receive buffers Section 19.6, “Programmer’s Model of Message Storage”. An additional Section 19.6.2.2, “MSCAN Transmit Buffer Priority Register (TBPR)” contains an 8-bit “Local Priority” field (PRIO). The remaining two bytes are used for time stamping of a message, if required (see Section 19.6.2.3, “MSCAN Time Stamp Register High (TSRH)”, Section 19.6.2.4, “MSCAN Time Stamp Register Low (TSRL)”).

To transmit a message, the CPU has to identify an available transmit buffer which is indicated by a set Transmitter Buffer Empty (TXEx) flag Section 19.5.2.7, “MSCAN Transmitter Flag Register (CANTFLG)”. If a transmit buffer is available, the CPU has to set a pointer to this buffer by writing to the CANTBSEL register (Section 19.5.2.11, “MSCAN Transmit Buffer Selection (CANTBSEL)”). This makes the respective buffer accessible within the CANTXFG address space Section 19.6, “Programmer’s Model of Message Storage”. The algorithmic feature associated with the CANTBSEL register simplifies the transmit buffer selection. In addition this scheme makes the handler software simpler as only one address area is applicable for the transmit process. In addition the required address space is minimized.

1. Reference the Bosch CAN 2.0A/B protocol specification dated September 1991.

The CPU then stores the identifier, the control bits and the data content into one of the transmit buffers. Finally, the buffer is flagged as ready for transmission by clearing the associated TXE flag.

The MSCAN then schedules the message for transmission and signals the successful transmission of the buffer by setting the associated TXE flag. A transmit interrupt Section 19.7.9.1, “Transmit Interrupt” is generated[1] when TXEx is set and can be used to drive the application software to re-load the buffer.

In case more than one buffer is scheduled for transmission when the CAN bus becomes available for arbitration, the MSCAN uses the “local priority” setting of the three buffers to determine the prioritization. For this purpose, every transmit buffer has an 8-bit local priority field (PRIO). The application software programs this field when the message is set up. The local priority reflects the priority of this particular message relative to the set of messages being transmitted from this node. The lowest binary value of the PRIO field is defined to be the highest priority. The internal scheduling process takes place whenever the MSCAN arbitrates for the bus. This is also the case after the occurrence of a transmission error.

When a high priority message is scheduled by the application software, it may become necessary to abort a lower priority message in one of the three transmit buffers. As messages that are already in transmission cannot be aborted, the user has to request the abort by setting the corresponding Abort Request bit (ABTRQ) Section 19.5.2.10, “MSCAN Transmitter Message Abort Acknowledge (CANTAAK)”. The MSCAN then grants the request, if possible, by: 1) setting the corresponding Abort Acknowledge flag (ABTAK) in the CANTAAK register, 2) setting the associated TXE flag to release the buffer, and 3) generating a transmit interrupt. The transmit interrupt handler software can tell from the setting of the ABTAK flag whether the message was aborted (ABTAK=1) or sent (ABTAK=0).

### 19.7.2.3 Receive Structures

The received messages are stored in a four stage input FIFO. The four message buffers are alternately mapped into a single memory area Figure 19-26. While the background receive buffer (RxBG) is exclusively associated with the MSCAN, the foreground receive buffer (RxFG) is addressable by the CPU Figure 19-26. This scheme simplifies the handler software as only one address area is applicable for the receive process.

All receive buffers have a size of 15 bytes to store the CAN control bits, the identifier (standard or extended), the data contents and a time stamp, if enabled (for details Section 19.6, “Programmer’s Model of Message Storage”)[2].

The Receiver Full flag (RXF) Section 19.5.2.5, “MSCAN Receiver Flag Register (CANRFLG)” signals the status of the foreground receive buffer. When the buffer contains a correctly received message with a matching identifier, this flag is set.

1. The transmit interrupt occurs only if not masked. A polling scheme can be applied on TXEx also.
2. Reference the Bosch CAN 2.0A/B protocol specification dated September 1991 for details.

On reception, each message is checked to see if it passes the filter (Section 19.7.3, “Identifier Acceptance Filter”) and in parallel, is written into the active RxBG. After successful reception of a valid message the MSCAN shifts the content of RxBG into the receiver FIFO[1], sets the RXF flag, and generates a receive interrupt Section 19.7.9.2, “Receive Interrupt” to the CPU[2]. The user’s receive handler has to read the received message from the RxFG and then reset the RXF flag to acknowledge the interrupt and to release the foreground buffer. A new message, which can follow immediately after the IFS field of the CAN frame, is received into the next available RxBG. If the MSCAN receives an invalid message in its RxBG (wrong identifier, transmission errors etc.) the actual contents of the buffer will be over-written by the next message. The buffer will then not be shifted into the FIFO.

When the MSCAN module is transmitting, the MSCAN receives its own transmitted messages into the background receive buffer, RxBG, but does not shift it into the receiver FIFO, generate a receive interrupt, or acknowledge its own messages on the CAN bus. The exception to this rule is in loop back mode Section 19.5.2.2, “MSCAN Control Register 1 (CANCTL1)” where the MSCAN treats its own messages exactly like all other incoming messages. The MSCAN receives its own transmitted messages in the event that it loses arbitration[3]. If arbitration is lost, the MSCAN must be prepared to become a receiver.

An overrun condition occurs when all receive message buffers in the FIFO are filled with correctly received messages with accepted identifiers and another message is correctly received from the bus with an accepted identifier. The latter message is discarded and an error interrupt with overrun indication is generated if enabled Section 19.7.9.4, “Error Interrupt”. The MSCAN is still able to transmit messages while the receiver FIFO being filled, but all incoming messages are discarded. As soon as a receive buffer in the FIFO is available again, new valid messages will be accepted.

## 19.7.3 Identifier Acceptance Filter

The MSCAN Identifier Acceptance Registers (Section 19.5.2.12, “MSCAN ID Acceptance Control Register (CANIDAC)”) define the acceptable patterns of the standard or extended identifier (ID10 - ID0 or ID28 - ID0). Any of these bits can be marked ‘don’t care’ in the MSCAN Identifier Mask Registers Section 19.5.2.16, “MSCAN ID Mask Register (CANIDMR0–CANIDMR7)”.

A filter hit is indicated to the application software by a set Receive Buffer Full flag (RXF=1) and three bits in the CANIDAC register Section 19.5.2.15, “MSCAN ID Acceptance Registers (CANIDAR0–CANIDAR7)”. These Identifier Hit flags (IDHIT2-0) clearly identify the filter section that caused the acceptance. They simplify the application software’s task to identify the cause of the receiver interrupt. In case more than one hit occurs (two or more filters match), the lower hit has priority.

1. Only if the RXF flag is not set.
2. The receive interrupt occurs only if not masked. A polling scheme can be applied on RXF also.
3. Reference the Bosch CAN 2.0A/B protocol specification dated September 1991 for details.

A very flexible programmable generic identifier acceptance filter has been introduced to reduce the CPU interrupt loading. The filter is programmable to operate in four different modes[1]:

- Two identifier acceptance filters, each to be applied to a) the full 29 bits of the extended identifier and to the following bits of the CAN 2.0B frame: Remote Transmission Request (RTR), Identifier Extension (IDE), and Substitute Remote Request (SRR) or b)[2] the 11 bits of the standard identifier plus the RTR and IDE bits of the CAN 2.0A/B messages. This mode implements two filters for a full length CAN 2.0B compliant extended identifier. Figure 19-27 shows how the first 32-bit filter bank (CANIDAR0-3, CANIDMR0-3) produces a filter 0 hit. Similarly, the second filter bank (CANIDAR4-7, CANIDMR4-7) produces a filter 1 hit.
- Four identifier acceptance filters, each to be applied to a) the 14 most significant bits of the extended identifier plus the SRR and IDE bits of CAN 2.0B messages or b) the 11 bits of the standard identifier, the RTR and IDE bits of CAN 2.0A/B messages. Figure 19-28 shows how the first 32-bit filter bank (CANIDAR0-3, CANIDMR0-3) produces filter 0 and 1 hits. Similarly, the second filter bank (CANIDAR4-7, CANIDMR4-7) produces filter 2 and 3 hits.
- Eight identifier acceptance filters, each to be applied to the first 8 bits of the identifier. This mode implements eight independent filters for the first 8 bits of a CAN 2.0A/B compliant standard identifier or a CAN 2.0B compliant extended identifier. Figure 19-29 shows how the first 32-bit filter bank (CANIDAR0-3, CANIDMR0-3) produces filter 0 to 3 hits. Similarly, the second filter bank (CANIDAR4-7, CANIDMR4-7) produces filter 4 to 7 hits.
- Closed filter. No CAN message is copied into the foreground buffer RxFG, and the RXF flag is never set.

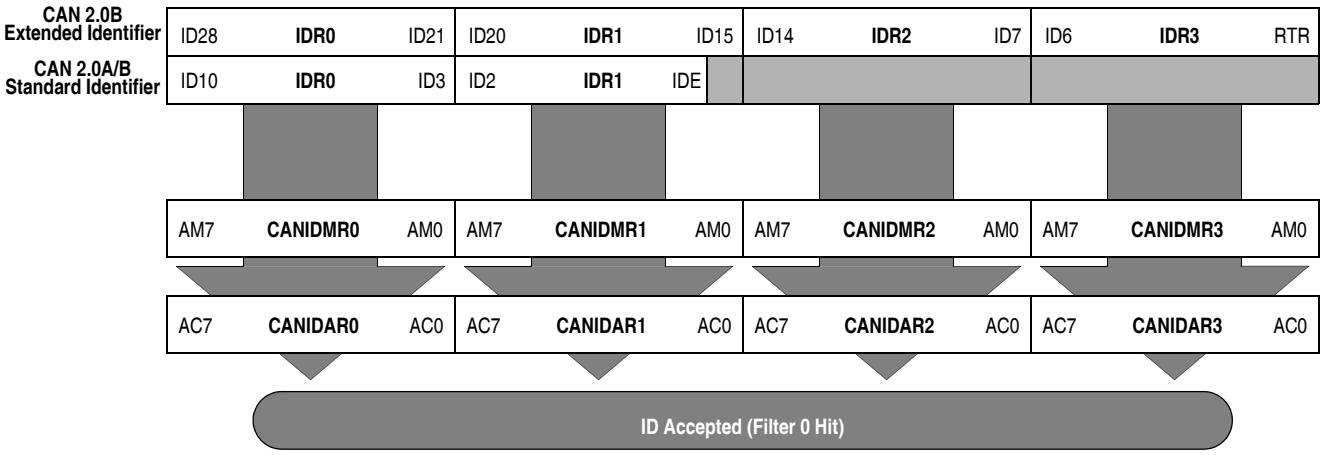



**Figure 19-27. 32-bit Maskable Identifier Acceptance Filter**

1. For a better understanding of references made within the filter mode description, reference the Bosch specification dated September 1991 which details the CAN 2.0A/B protocol.
2. Although this mode can be used for standard identifiers, it is recommended to use the four or eight identifier acceptance filters for standard identifiers

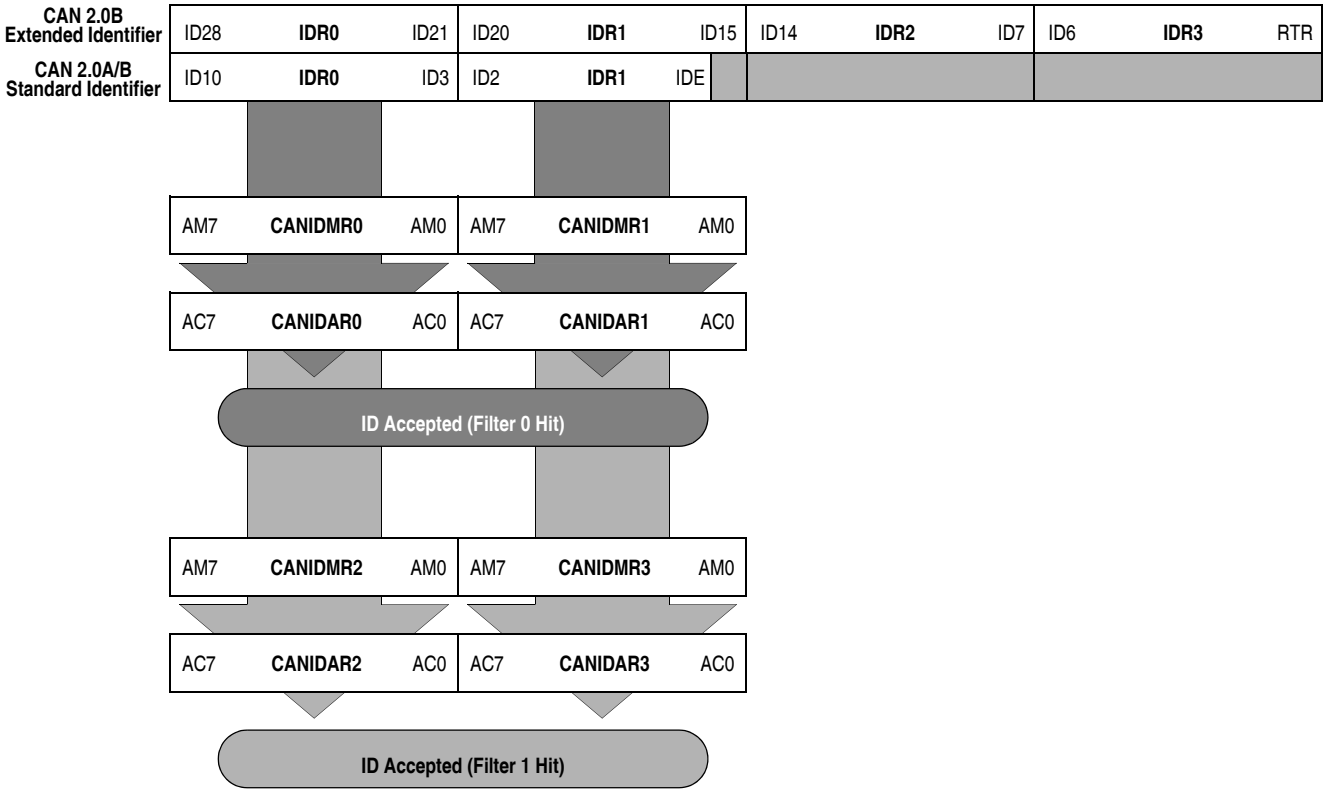



**Figure 19-28. 16-bit Maskable Identifier Acceptance Filters**

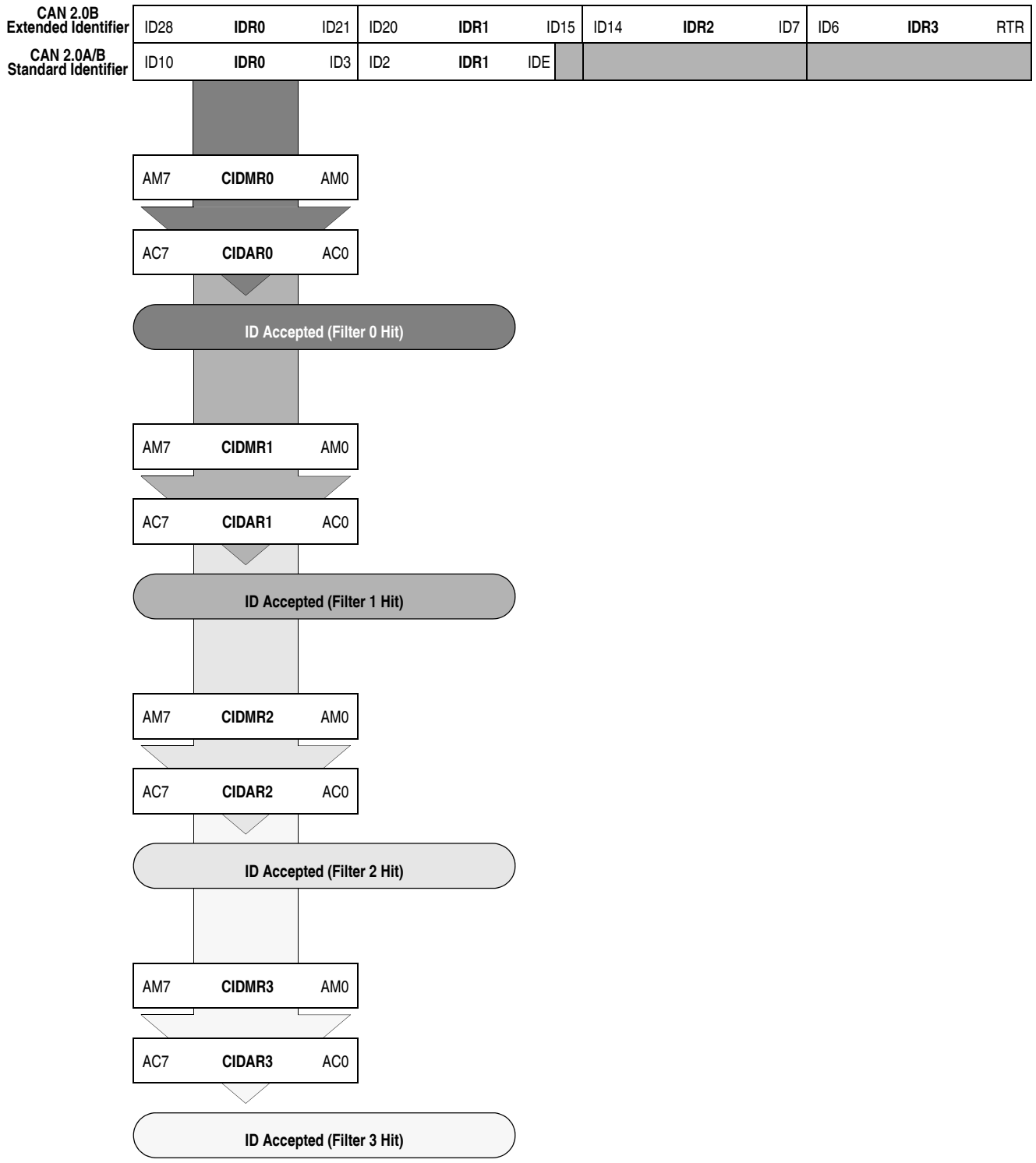

CAN 2.0B Extended Identifier
ID28 IDR0 ID21 ID20 IDR1 ID15 ID14 IDR2 ID7 ID6 IDR3 RTR
CAN 2.0A/B Standard Identifier
ID10 IDR0 ID3 ID2 IDR1 IDE
AM7 CIDMR0 AM0
AC7 CIDAR0 AC0
ID Accepted (Filter 0 Hit)
AM7 CIDMR1 AM0
AC7 CIDAR1 AC0
ID Accepted (Filter 1 Hit)
AM7 CIDMR2 AM0
AC7 CIDAR2 AC0
ID Accepted (Filter 2 Hit)
AM7 CIDMR3 AM0
AC7 CIDAR3 AC0
ID Accepted (Filter 3 Hit)

**Figure 19-29. 8-bit Maskable Identifier Acceptance Filters**

### 19.7.4 Protocol Violation Protection

The MSCAN protects the user from accidentally violating the CAN protocol through programming errors. The protection logic implements the following features:

- The receive and transmit error counters cannot be written or otherwise manipulated.
- All registers which control the configuration of the MSCAN cannot be modified while the MSCAN is on-line. The MSCAN has to be in Initialization Mode. The corresponding INITRQ/INITAK handshake bits in the CANCTL0/CANCTL1 registers Section 19.5.2.1, “MSCAN Control Register 0 (CANCTL0)” serve as a lock to protect the following registers:
  - MSCAN Control 1 Register (CANCTL1)
  - MSCAN Bus Timing Registers 0 and 1 (CANBTR0, CANBTR1)
  - MSCAN Identifier Acceptance Control Register (CANIDAC)
  - MSCAN Identifier Acceptance Registers (CANIDAR0-7)
  - MSCAN Identifier Mask Registers (CANIDMR0-7)
- The TXCAN pin is immediately forced to a recessive state when the MSCAN goes into the Power Down Mode or Initialization Mode (see Section 19.7.8.6, “MSCAN Power Down Mode” and Section 19.7.8.5, “MSCAN Initialization Mode”).
- The MSCAN enable bit (CANE) is only writable once in normal modes as further protection against inadvertently disabling the MSCAN.

### 19.7.5 Clock System

Figure 19-30 shows the structure of the MSCAN clock generation circuitry. With this flexible clocking scheme, the MSCAN is able to handle CAN bus rates ranging from 10 Kbps up to 1 Mbps.

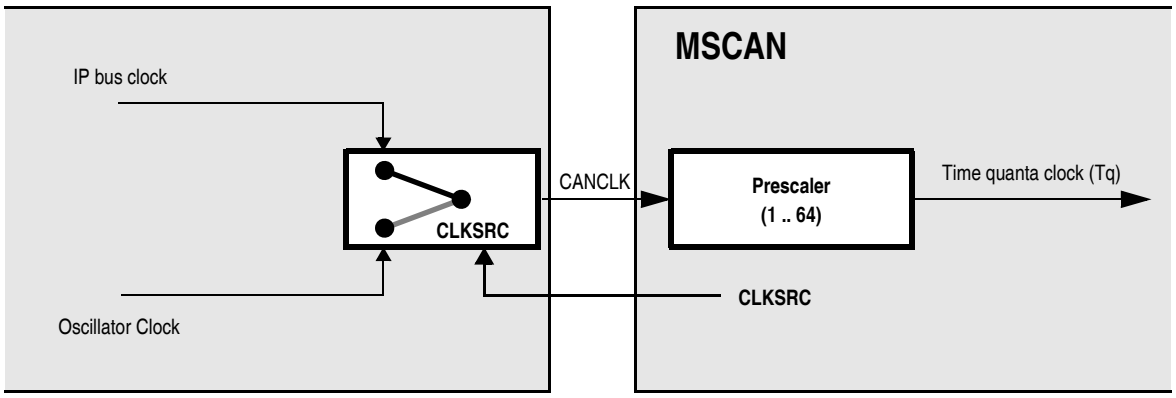



**Figure 19-30. MSCAN Clocking Scheme**

The clock source bit (CLKSRC) in the CANCTL1 register Section 19.5.2.2, “MSCAN Control Register 1 (CANCTL1)” defines whether the internal CANCLK is connected to the output of the system oscillator clock (SYS_XTAL_IN) or to the IP bus clock.

**NOTE**

Both MSCAN modules can have different selected clock sources. To select the oscillator clock the CLKSRC bit in the CANCTL1 register must be set.

The clock source has to be chosen such that the tight oscillator tolerance requirements (up to 0.4%) of the CAN protocol are met. Additionally, for high CAN bus rates (1 Mbps), a 45%-55% duty cycle of the clock is required.

Because the Bus Clock is generated from a PLL, it is recommended to select the Oscillator Clock rather than the Bus Clock due to jitter considerations, especially at the faster CAN bus rates.

A programmable prescaler generates the time quanta (Tq) clock from CANCLK. A time quantum is the atomic unit of time handled by the MSCAN.

$$f_{Tq} = \frac{f_{CANCLK}}{(Prescaler\ \ value)}$$

A bit time is subdivided into three segments[1] [2] (reference Figure 19-31):

- SYNC_SEG: This segment has a fixed length of one time quantum. Signal edges are expected to happen within this section.
- Time Segment 1: This segment includes the PROP_SEG and the PHASE_SEG1 of the CAN standard. It can be programmed by setting the parameter TSEG1 to consist of 4 to 16 time quanta.
- Time Segment 2: This segment represents the PHASE_SEG2 of the CAN standard. It can be programmed by setting the TSEG2 parameter to be 2 to 8 time quanta long.

$$Bit\ \ Rate = \frac{f_{Tq}}{(number\ \ of\ \ Time\ \ Quanta)}$$

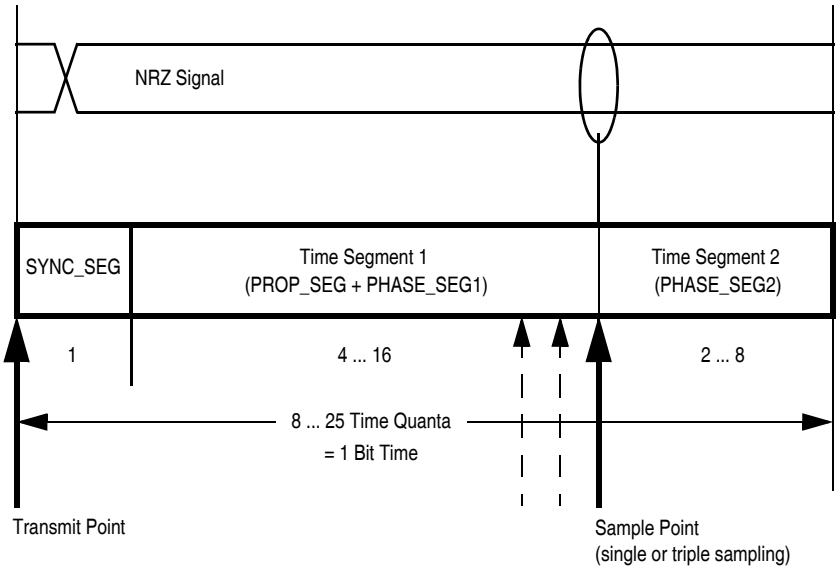



**Figure 19-31. Segments within the Bit Time**

1. For further explanation of the under-lying concepts please refer to ISO/DIS 11519-1, Section 10.3.
2. Reference the Bosch CAN 2.0A/B protocol specification dated September 1991 for bit timing.

**Table 19-29. Time Segment Syntax**

| Syntax | Description |
|---|---|
| SYNC_SEG | System expects transitions to occur on the bus during this period. |
| Transmit Point | A node in transmit mode transfers a new value to the CAN bus at this point. |
| Sample Point | A node in receive mode samples the bus at this point. If the three samples per bit option is selected, then this point marks the position of the third sample. |

The Synchronization Jump Width[1] can be programmed in a range of 1 to 4 time quanta by setting the SJW parameter.

The above parameters are set by programming the MSCAN Bus Timing Registers (CANBTR0, CANBTR1) (see Section 19.5.2.1, “MSCAN Control Register 0 (CANCTL0)” and Section 19.5.2.4, “MSCAN Bus Timing Register 1 (CANBTR1)”).

Table 19-30 gives an overview of the CAN compliant segment settings and the related parameter values.

**NOTE**

It is the user’s responsibility to ensure the bit time settings are in compliance with the CAN standard.

**Table 19-30. CAN Standard Compliant Bit Time Segment Settings**

| Time Segment 1 | TSEG1 | Time Segment 2 | TSEG2 | Synchronization Jump Width | SJW |
|---|---|---|---|---|---|
| 5 .. 10 | 4 .. 9 | 2 | 1 | 1 .. 2 | 0 .. 1 |
| 4 .. 11 | 3 .. 10 | 3 | 2 | 1 .. 3 | 0 .. 2 |
| 5 .. 12 | 4 .. 11 | 4 | 3 | 1 .. 4 | 0 .. 3 |
| 6 .. 13 | 5 .. 12 | 5 | 4 | 1 .. 4 | 0 .. 3 |
| 7 .. 14 | 6 .. 13 | 6 | 5 | 1 .. 4 | 0 .. 3 |
| 8 .. 15 | 7 .. 14 | 7 | 6 | 1 .. 4 | 0 .. 3 |
| 9 .. 16 | 8 .. 15 | 8 | 7 | 1 .. 4 | 0 .. 3 |

## 19.7.6 Timer Link

The MSCAN generates an internal time stamp whenever a valid frame is received or transmitted and the TIME bit is enabled. Because the CAN specification defines a frame to be valid if no errors occur before the End of Frame (EOF) field is transmitted successfully, the actual value of an internal timer is written at EOF to the appropriate time stamp position within the transmit buffer. For receive frames the time stamp is written to the receive buffer.

1. Reference the Bosch CAN 2.0A/B protocol specification dated September 1991 for bit timing.

## 19.7.7 Modes of Operation

### 19.7.7.1 Normal Modes

The MSCAN module behaves as described within this specification in all normal modes.

### 19.7.7.2 Listen-Only Mode

In an optional bus monitoring mode (Listen-Only), the CAN node is able to receive valid data frames and valid remote frames, but it sends only “recessive” bits on the CAN bus. In addition it cannot start a transmission. If the MAC sub-layer is required to send a “dominant” bit (ACK bit, overload flag, active error flag), the bit is rerouted internally so that the MAC sub-layer monitors this “dominant bit, although the CAN bus may remain in recessive state externally.

## 19.7.8 Low Power Options

If the MSCAN is disabled (CANE=0), the MSCAN clocks are stopped for power savings.

If the MSCAN is enabled (CANE=1), the MSCAN has two additional modes with reduced power consumption, compared to normal mode: Sleep and Power Down Mode. In Sleep Mode power consumption is reduced by stopping all clocks except those to access the registers from the CPU side. In Power Down Mode, all clocks are stopped and no power is consumed.

Table 19-31 summarizes the combinations of MSCAN and CPU modes. A particular combination of modes is entered by the given settings on the CSWAI and SLPRQ/SLPAK bits.

For all modes, an MSCAN Wake-Up interrupt can only occur if the MSCAN is in Sleep Mode (SLPRQ=1 and SLPAK=1), wake-up functionality is enabled (WUPE=1) and the Wake-Up interrupt is enabled (WUPIE=1).

**Table 19-31. CPU vs. MSCAN Operating Modes**

| Power Mode | MSCAN Mode | | | |
|---|---|---|---|---|
| | Normal | Power Down | Sleep | (CANE=0) |
| **Full Power** | CSWAI = X[1]<br>SLPRQ = 0<br>SLPAK = 0 | | CSWAI = X<br>SLPRQ = 1<br>SLPAK = 1 | CSWAI = X<br>SLPRQ = X<br>SLPAK = X |
| **Sleep** | CSWAI = 0<br>SLPRQ = 0<br>SLPAK = 0 | CSWAI = 1<br>SLPRQ = X<br>SLPAK = X | CSWAI = 0<br>SLPRQ = 1<br>SLPAK = 1 | CSWAI = X<br>SLPRQ = X<br>SLPAK = X |
| **Deep Sleep** | | CSWAI = X<br>SLPRQ = X<br>SLPAK = X | CSWAI = X<br>SLPRQ = 1<br>SLPAK = 1 | CSWAI = X<br>SLPRQ = X<br>SLPAK = X |

1 ‘X’ means don’t care.

### 19.7.8.1 CPU Run Mode

As can be seen in Table 19-31, only MSCAN Sleep Mode is available as low power option, when CPU is in run mode.

### 19.7.8.2 CPU Sleep Mode

While the CPU is in Sleep Mode, the MSCAN can be operated in Normal Mode and generate interrupts (registers can be accessed via background debug mode). The MSCAN can also operate in any of the low power modes depending on the values of the SLPRQ/SLPAK and CSWAI bits as seen in Table 19-31.

### 19.7.8.3 CPU Deep Sleep Mode

In Deep Sleep Mode, the MSCAN operates in Power Down mode regardless of the value of the SLPRQ/SLPAK and CSWAI bits Table 19-31.

### 19.7.8.4 MSCAN Sleep Mode

The CPU can request the MSCAN to enter this low power mode by asserting the SLPRQ bit in the CANCTL0 register. The time when the MSCAN enters Sleep Mode depends on a fixed synchronization delay and its current activity:

- If it is transmitting, it continues to transmit until the entire message is transmitted and then goes into Sleep Mode.
- If it is receiving, it waits for the end of this message and then goes into Sleep Mode.
- If it is neither transmitting nor receiving, it immediately goes into Sleep Mode.

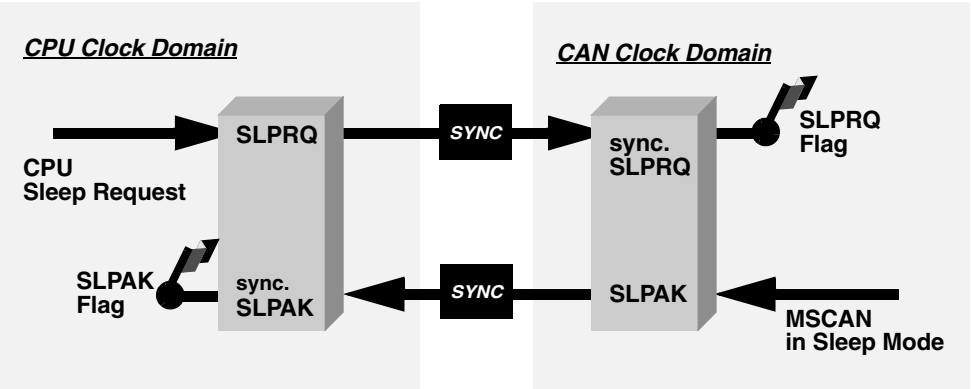



**Figure 19-32. Sleep Request / Acknowledge Cycle**

**NOTE**

The application software must avoid setting up a transmission (by clearing one or more TXEx flag(s)) and immediately request Sleep Mode (by setting SLPRQ). It depends on the exact sequence of operations whether the MSCAN starts transmitting or goes into Sleep Mode directly.

If Sleep Mode is active, the SLPRQ and SLPAK bits are set (Figure 19-32). The application software must use SLPAK as a handshake indication for the request (SLPRQ) to go into Sleep Mode.

When in Sleep Mode (SLPRQ=1 and SLPAK=1), the MSCAN stops its internal clocks. However, clocks to allow register accesses from the CPU side still run. If the MSCAN is in Bus-Off state, it stops counting the 128*11 consecutive recessive bits due to the stopped clocks. The TXCAN pin remains in a recessive state. If RXF=1, the message can be read and RXF can be cleared. Shifting a new message into the foreground buffer of the receiver FIFO (RxFG) does not take place while in Sleep Mode. It is possible to access the transmit buffers and to clear the associated TXE flags. No message abort takes place while in Sleep Mode. If the WUPE bit in CANCLT0 is not asserted, the MSCAN will mask any activity it detects on CAN. The RXCAN pin is therefore held internally in a recessive state. This locks the MSCAN in Sleep Mode (Figure 19-33).

The MSCAN is only able to leave Sleep Mode (wake-up) when

- bus activity occurs and WUPE=1 or
- the MCU clears the SLPRQ bit

**NOTE**

The MCU cannot clear the SLPRQ bit before Sleep Mode (SLPRQ=1 and SLPAK=1) is active.

After wake-up, the MSCAN waits for 11 consecutive recessive bits to synchronize to the bus. As a consequence, if the MSCAN is woken-up by a CAN frame, this frame is not received. The receive message buffers (RxFG and RxBG) contain messages if they were received before Sleep Mode was entered. All pending actions will be executed upon wake-up; copying of RxBG into RxFG, message aborts and message transmissions. If the MSCAN is still in Bus-Off state after Sleep Mode was left, it continues counting the 128*11 consecutive recessive bits.

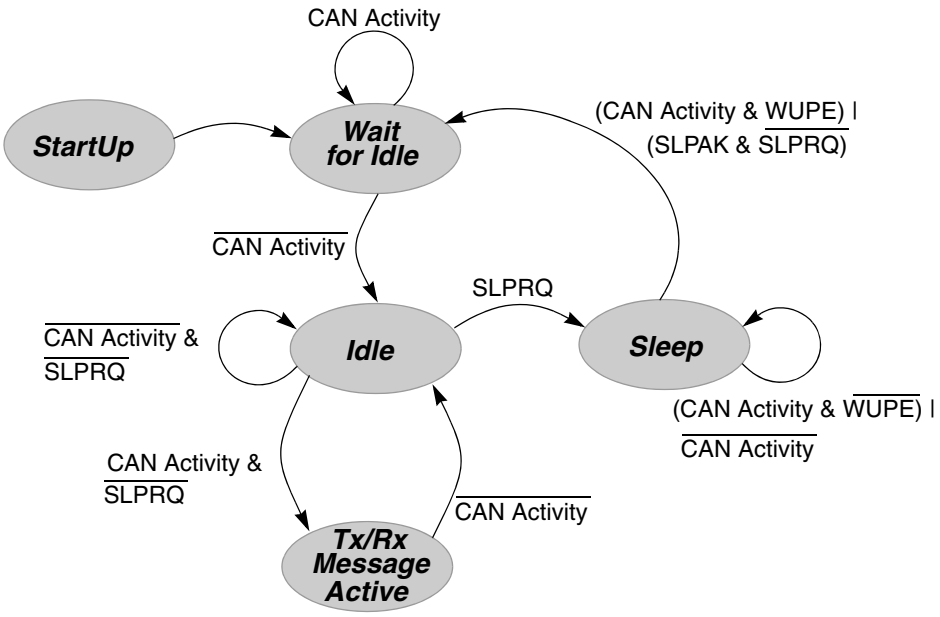



**Figure 19-33. Simplified State Transitions for Entering/Leaving Sleep Mode**

### 19.7.8.5 MSCAN Initialization Mode

In Initialization Mode, any ongoing transmission or reception is immediately aborted and synchronization to the bus is lost potentially causing CAN protocol violations. To protect the CAN bus system from fatal consequences of violations, the MSCAN immediately drives the TXCAN pin into a recessive state.

**NOTE**

The user is responsible for ensuring that the MSCAN is not active when Initialization Mode is entered. The recommended procedure is to bring the MSCAN into Sleep Mode (SLPRQ=1 and SLPAK=1) before setting the INITRQ bit in the CANCTL0 register. Otherwise the abort of an ongoing message can cause an error condition and can have an impact on the other bus devices.

In Initialization Mode, the MSCAN is stopped. However, interface registers can still be accessed. This mode is used to reset the CANTCTL0, CANRFLG, CANRIER, CANTFLG, CANTIER, CANTARQ, CANTAAK, CANTBSEL registers to their default values. In addition it enables the configuration of the CANBTR0, CANBTR1 bit timing registers, CANIDAC and the CANIDAR, CANIDMR message filters. Section 19.5.2.1, “MSCAN Control Register 0 (CANCTL0)” for a detailed description of the Initialization Mode.

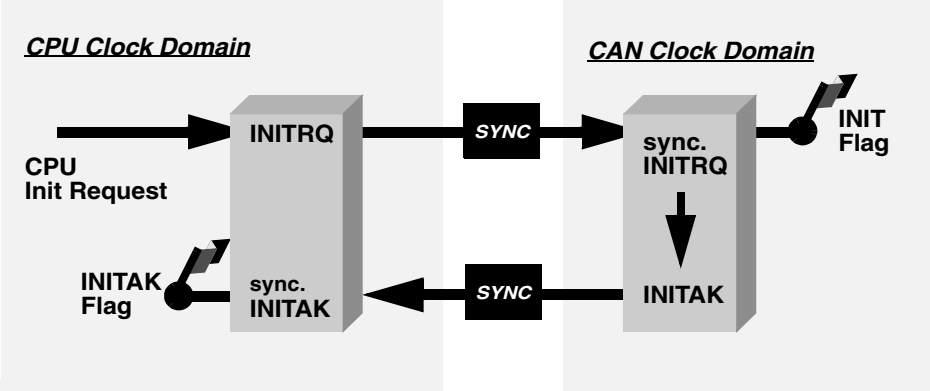



**Figure 19-34. Initialization Request/Acknowledge Cycle**

Due to independent clock domains within the MSCAN the INITRQ has to be synchronized to all domains by using a special handshake mechanism. This handshake causes additional synchronization delay (). If there is no message transfer ongoing on the CAN bus, the minimum delay will be two additional bus clocks and three additional CAN clocks. When all parts of the MSCAN are in Initialization Mode the INITAK flag is set. The application software must use INITAK as a handshake indication for the request (INITRQ) to go into Initialization Mode.

**NOTE**

The MCU cannot clear the INITRQ bit before Initialization Mode (INITRQ=1 and INITAK=1) is active.

#### 19.7.8.6 MSCAN Power Down Mode

The MSCAN is in Power Down Mode when Table 19-31

- The CPU is in Deep Sleep Mode or
- The CPU is in SLEEP Mode and the CSWAI bit is set.

When entering the Power Down Mode, the MSCAN immediately stops all ongoing transmissions and receptions, potentially causing CAN protocol violations. To protect the CAN bus system from fatal consequences of violations to the above rule, the MSCAN immediately drives the TXCAN pin into a recessive state. In Power-Down modes, no registers can be accessed.

**NOTE**

The user is responsible for ensuring that the MSCAN is not active when Power Down Mode is entered. The recommended procedure is to bring the MSCAN into Sleep Mode before the STOP or WAI instruction (if CSWAI is set) is executed. Otherwise the abort of an ongoing message can cause an error condition and can have an impact on the other bus devices.

In Power Down Mode, all clocks are stopped and no registers can be accessed. If the MSCAN was not in Sleep Mode before Power Down Mode became active, the module would perform an internal recovery cycle after powering up. This causes some fixed delay before the module enters Run Mode again.

#### 19.7.8.7 Programmable Wake-Up Function

The MSCAN can be programmed to wake-up the MSCAN as soon as bus activity is detected (see control bit WUPE in Section 19.5.2.1, “MSCAN Control Register 0 (CANCTL0)”).

### 19.7.9 Description of Interrupt Operation

The MSCAN supports one interrupt vector mapped onto eight different interrupt sources, any of which can be individually masked (for details see sections Section 19.5.2.6, “MSCAN Receiver Interrupt Enable Register (CANRIER)” to Section 19.5.2.8, “MSCAN Transmitter Interrupt Enable Register (CANTIER)”):

#### 19.7.9.1 Transmit Interrupt

At least one of the three transmit buffers is empty (not scheduled) and can be loaded to schedule a message for transmission. The TXEx flag of the empty message buffer is set.

#### 19.7.9.2 Receive Interrupt

A message is successfully received and shifted into the foreground buffer (RxFG) of the receiver FIFO. This interrupt is generated immediately after receiving the EOF symbol. The RXF flag is set. If there are multiple messages in the receiver FIFO, the RXF flag is set as soon as the next message is shifted to the foreground buffer.

#### 19.7.9.3 Wake-Up Interrupt

Activity on the CAN bus occurred during MSCAN internal Sleep Mode and WUPE Section 19.5.2.1, “MSCAN Control Register 0 (CANCTL0)” enabled.

#### 19.7.9.4 Error Interrupt

An overrun of the receiver FIFO, error, warning or Bus-Off condition occurred. The Section 19.5.2.5, “MSCAN Receiver Flag Register (CANRFLG)” indicates one of the following conditions:

- Overrun

  An overrun condition of the receiver FIFO as described in Section 19.7.2.3, “Receive Structures” occurred.
- CAN Status Change

  The actual value of the Transmit and Receive Error Counters control the bus state of the MSCAN. As soon as the error counters skip into a critical range (Tx/Rx-Warning, Tx/Rx-Error, Bus-Off) the MSCAN flags an error condition. The status change, which caused the error condition, is indicated by the TSTAT and RSTAT flags (see section Section 19.5.2.5, “MSCAN Receiver Flag Register (CANRFLG)” and Section 19.5.2.6, “MSCAN Receiver Interrupt Enable Register (CANRIER)”).

### 19.7.10 Interrupt Acknowledge

Interrupts are directly associated with one or more status flags in either the Section 19.5.2.5, “MSCAN Receiver Flag Register (CANRFLG)” or the Section 19.5.2.7, “MSCAN Transmitter Flag Register (CANTFLG)”. Interrupts are pending as long as one of the corresponding flags is set. The flags in the above registers must be reset within the interrupt handler to handshake the interrupt. The flags are reset by writing a “1” to the corresponding bit position. A flag cannot be cleared if the respective condition still prevails.

**NOTE**

It must be guaranteed that the CPU only clears the bit causing the current interrupt. For this reason, bit manipulation instructions (*BSET*) must not be used to clear interrupt flags. These instructions may cause accidental clearing of interrupt flags which are set after entering the current interrupt service routine.

### 19.7.11 Recovery from STOP or WAIT

The MSCAN can recover from Sleep Mode via the Wake-Up interrupt. This interrupt can only occur if the MSCAN is in Sleep Mode (SLPRQ=1 and SLPAK=1), the wake-up option is enabled (WUPE=1) and the Wake-Up interrupt is enabled (WUPIE=1).

# Chapter 20
# Byte Data Link Controller (BDLC)

## 20.1 Overview

The BDLC module is a serial communication module which allows the user to send and receive messages across a Society of Automotive Engineers (SAE) J1850 serial communication network. The user's software handles each transmitted or received message on a byte-by-byte basis, while the BDLC performs all of the network access, arbitration, message framing and error detection duties.

It is recommended that the reader be familiar with the operation and requirements of the SAE J1850 protocol as described in the document "SAE Standard J1850 Class B Data Communications Network Interface" prior to proceeding with this specification.

The BDLC module is designed in a modular structure for use as an IP block. A general working knowledge of the IP bus signals and bus control is assumed in the writing of this document.

## 20.2 Features

Features of the BDLC module include the following:

- SAE J1850 Class B Data Communications Network Interface Compatible and ISO Compatible for Low-Speed (≤ 125 Kbps) Serial Data Communications in Automotive Applications
- 10.4 Kbps Variable Pulse Width (VPW) Bit Format
- Digital Noise Filter
- Digital Loopback Mode
- 4X Receive and Transmit Mode, 41.6 Kbps, Supported
- BREAK symbol generation Supported
- Block Mode Receive and Transmit Supported
- Collision Detection
- Hardware Cyclical Redundancy Check (CRC) Generation and Checking
- Dedicated Register for Symbol Timing Adjustments
- IP bus Interface
- In-Frame Response (IFR) Types 0, 1, 2, and 3 Supported
- Polling and CPU Interrupt Generation with Vector Lookup Available

## 20.3 Modes of Operation

The BDLC module has 6 main modes of operation which interact with the power supplies, pins, and the rest of the MCU as shown below.

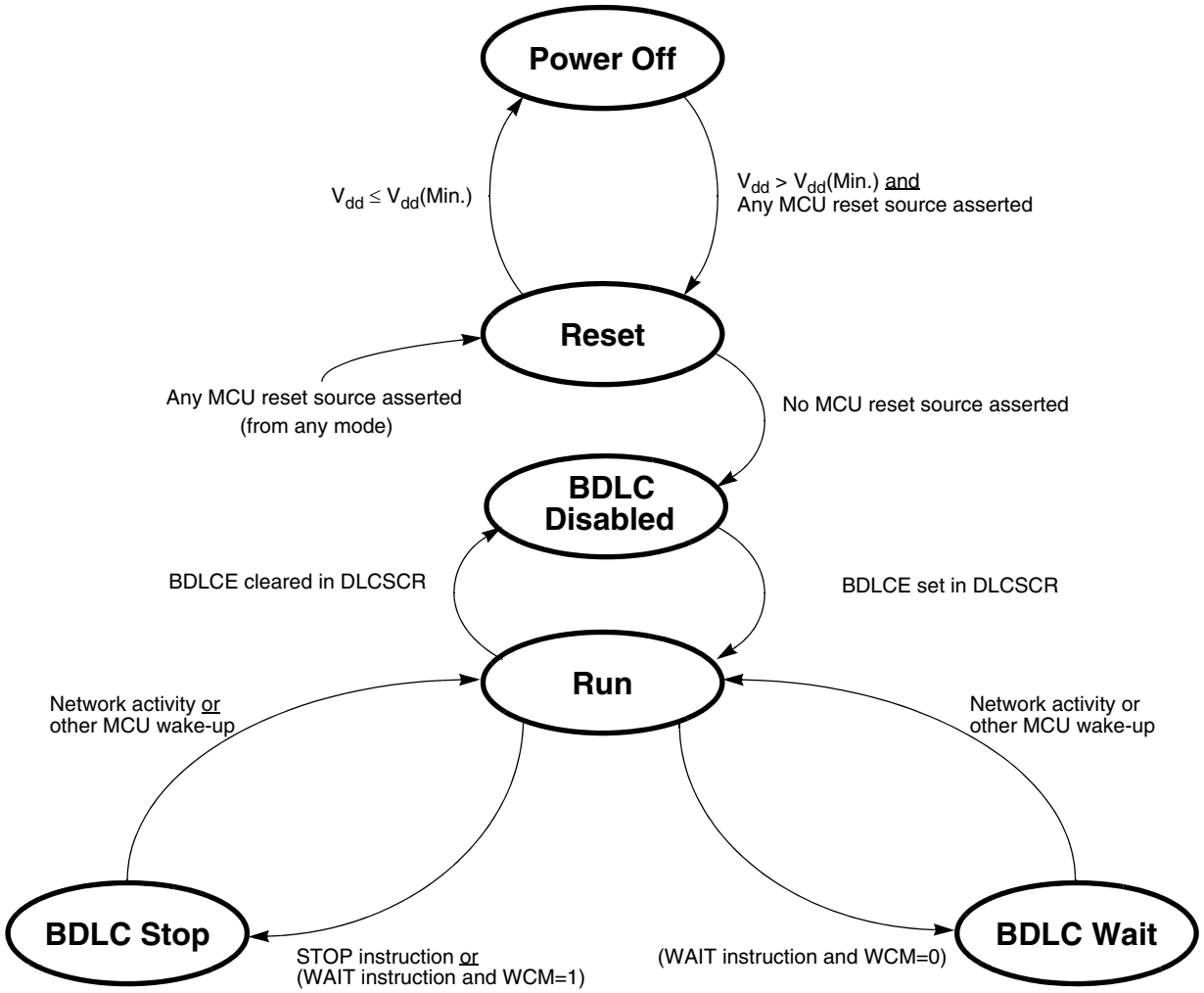



**Figure 20-1. BDLC Operating Modes State Diagram**

- Power Off

  This mode is entered from the Reset mode whenever the BDLC module supply voltage $V_{dd}$ drops below its minimum specified value for the BDLC module to guarantee operation. The BDLC module will be placed in the Reset mode by a system Low Voltage Reset (LVR) before being powered down. In this mode, the pin input and output specifications are not guaranteed.

- Reset

  This mode is entered from the Power Off mode whenever the BDLC module supply voltage $V_{dd}$ rises above its minimum specified value ($V_{dd(MIN)}$) and some MCU reset source is asserted. To prevent the BDLC from entering an unknown state, the internal MCU reset is asserted while powering up the BDLC module. BDLC Reset mode is also entered from any other mode as soon as one of the MCUs possible reset sources (e.g. LVR, POR, COP watchdog, Reset pin etc.) is asserted.

  In this mode, the internal BDLC module voltage references are operative, $V_{dd}$ is supplied to the internal circuits, which are held in their reset state and the internal BDLC module system clock is running. Registers will assume their reset condition. Outputs are held in their programmed Reset state, inputs and network activity are ignored.

- BDLC Disabled

  This mode is entered from the Reset mode after all MCU reset sources are no longer asserted. It is entered from the Run mode whenever the BDLCE bit in the BDLC Control Register is cleared.

  In this mode the mux interface clock ($f_{bdlc}$) is stopped to conserve power and allow the BDLC module to be configured for proper operation on the J1850 bus. The IP bus interface clocks are left running in this mode to allow access to all BDLC module registers for initialization.

- Run

  This mode is entered from the BDLC Disabled mode when the BDLCE bit in the BDLC Control Register is set. It is entered from the BDLC Wait mode whenever activity is sensed on the J1850 bus or some other MCU source wakes the CPU out of Wait mode.

  It is entered from the BDLC Stop mode whenever network activity is sensed or some other MCU source wakes the CPU out of Stop mode. Messages will not be received properly until the clocks have stabilized and the CPU is also in the Run mode.

- BDLC Wait

  This power conserving mode is automatically entered from the Run mode whenever the CPU executes a WAIT instruction and if the WCM bit in the BDLC Control Register 1 register is previously cleared. In this mode, the BDLC module internal clocks continue to run. Any activity on the J1850 network will cause the BDLC module to exit BDLC Wait mode and generate an unmaskable interrupt of the CPU. This wakeup interrupt state is reflected in the BDLC State Vector Register, encoded as the highest priority interrupt. This interrupt can be cleared by the CPU with a read of the BDLC State Vector Register.

- Wakeup from BDLC Wait with CPU in WAIT

  If the CPU executes the WAIT instruction and the BDLC module enters the WAIT mode (WCM = 0), the clocks to the BDLC module as well as the clocks in the MCU continue to run. Therefore, the message which wakes up the BDLC module from WAIT and the CPU from WAIT mode will also be received correctly by the BDLC module. This is because all of the required

clocks continue to run in the BDLC module in WAIT mode.The wakeup behavior of the BDLC module applies regardless of whether the BDLC module is in normal or 4X mode when the WAIT instruction is executed.

- BDLC Stop

  This power conserving mode is automatically entered from the Run mode whenever the CPU executes a STOP instruction, or if the CPU executes a WAIT instruction and the WCM bit in the BDLC Control Register 1 register is previously set. In this mode, the BDLC internal clocks are stopped. Any activity on the network will cause the BDLC module to exit BDLC Stop mode and generate an unmaskable interrupt of the CPU. This wakeup interrupt state is reflected in the BDLC State Vector Register, encoded as the highest priority interrupt. This interrupt can be cleared by the CPU with a read of the BDLC State Vector Register. Depending upon which low-power mode instruction the CPU executes to cause the BDLC module to enter BDLC Stop, the message which wakes up the BDLC module (and the CPU) may or may not be received. There are two different possibilities, both of which is described below. These descriptions apply regardless of whether the BDLC module is in normal or 4X mode when the STOP or WAIT instruction is executed.

- Wakeup from BDLC Stop with CPU in STOP

  When the CPU executes the STOP instruction, all clocks in the MCU, including clocks to the BDLC module, are turned off. Therefore, the message which wakes up the BDLC module and the CPU from STOP mode will not be received. This is due primarily to the amount of time required for the MCUs oscillator to stabilize before the clocks can be applied internally to the other MCU modules, including the BDLC module.

- Wakeup from BDLC Stop with CPU in WAIT

  If the CPU executes the WAIT instruction and the BDLC module enters the Stop mode (WCM = 1), the clocks to the BDLC module are turned off, but the clocks in the MCU continue to run. Therefore, the message which wakes up the BDLC module from Stop and the CPU from WAIT mode will be received correctly by the BDLC module. This is because very little time is required for the CPU to turn the clocks to the BDLC module back on once the wakeup interrupt occurs.

**NOTE**

While the BDLC module will correctly receive a message which arrives when the BDLC module is in Stop mode or Wait mode and the MCU is in WAIT mode, if the user enters this mode while a message is being received, the data in the message will become corrupted. This is due to the steps required for the BDLC module to resume operation upon exiting Stop mode or Wait mode, and its subsequent resynchronization with the SAE J1850 bus.

- Digital Loopback

  When a bus fault has been detected, the digital loopback mode is used to determine if the fault condition is caused by failure in the node's internal circuits or elsewhere in the network, including the node's analog physical interface. In this mode, the input to the digital filter is disconnected from the receive pin input (RXB). The input to the digital filter is then connected to the transmitter output to form the loopback connection. The transmit pin (TXB) is negated and will always drive

a passive state onto the bus. Digital loopback mode is entered by setting the DLOOP bit in Section 20.7.3.3, “BDLC Control Register 2 (DLCBCR2)”.

- Normal and Emulation Mode Operation

  The BDLC module operates in the same manner in all Normal and Emulation Modes. All BDLC module registers can be read and written except those that are reserved, unimplemented, or write once. The user must be careful not to unintentionally write a register when using 16-bit writes in order to avoid unexpected BDLC module behavior.

- Special Mode Operation

  Some aspects of BDLC module operation can be modified in special test mode. This mode is reserved for internal use only.

- Low Power Options

  The BDLC module can save power in Disabled, Wait, and Stop modes. A complete description of what the BDLC module does while in a low power mode can be found in Section 20.3, “Modes of Operation”.

Figure 20-2 shows the organization of the BDLC module. The Buffers provide storage for data received and data to be transmitted onto the J1850 bus. The Protocol Handler is responsible for the encoding and decoding of data bits and special message symbols during transmission and reception. The MUX Interface provides the link between the BDLC digital section and the analog Physical Interface. The wave shaping, driving and digitizing of data is performed by the Physical Interface.

**NOTE**

The Physical Interface is not implemented in the BDLC module and must be provided externally.

The main functional blocks of the BDLC module are explained in greater detail in the following sections.

Use of the BDLC module in message networking fully implements the “SAE Standard J1850 Class B Data Communication Network Interface” specification.

## 20.4 Block Diagram

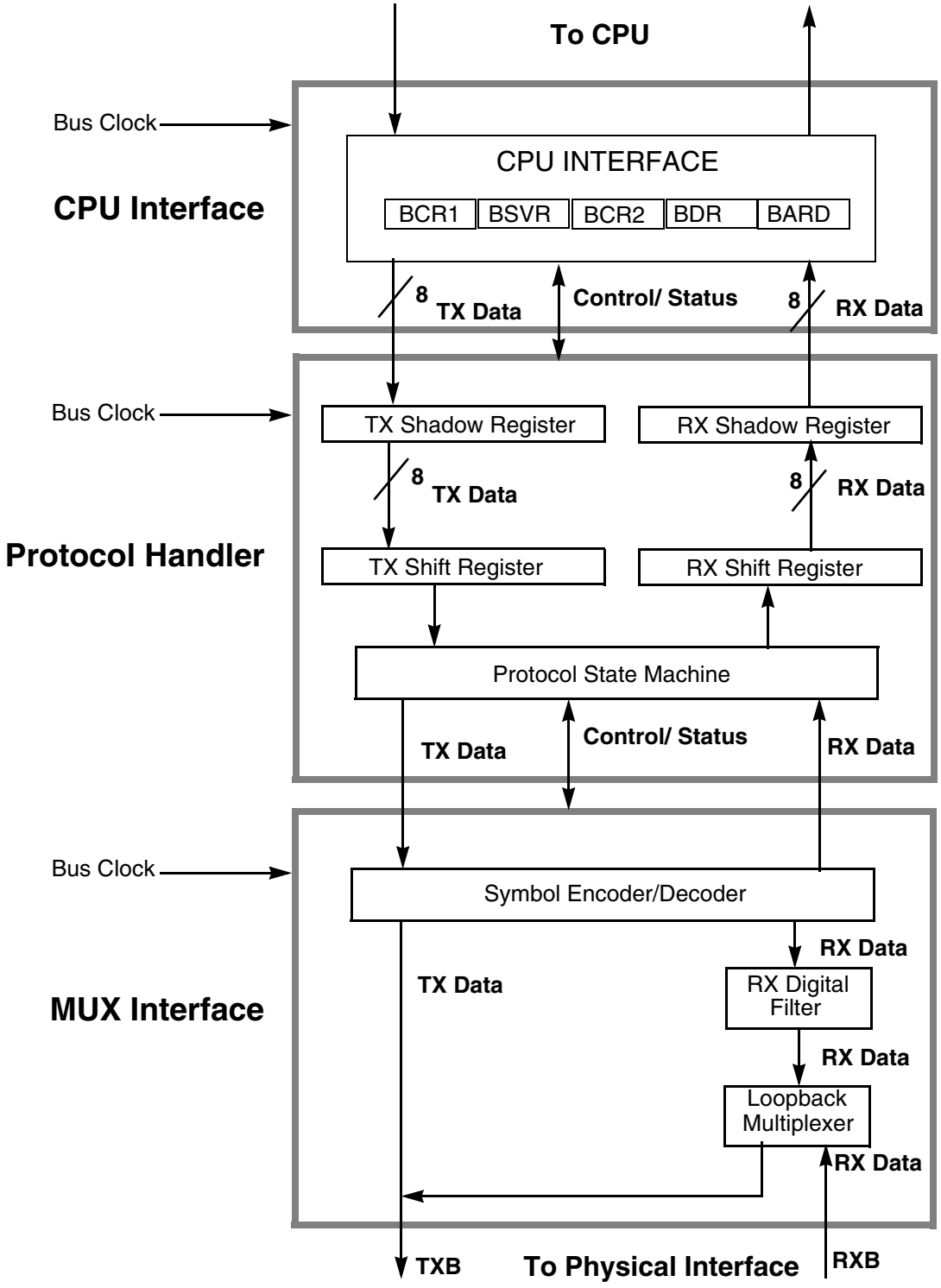



**Figure 20-2. BDLC Block Diagram**

## 20.5 Signal Description

## 20.6 Overview

The BDLC module has a total of 2 external pins.

### 20.6.1 Detailed Signal Descriptions

#### 20.6.1.1 TXB - BDLC Transmit Pin

The TXB pin serves as the transmit output channel for the BDLC module.

#### 20.6.1.2 RXB - BDLC Receive Pin

The RXB pin serves as the receive input channel for the BDLC module.

## 20.7 Memory Map and Registers

### 20.7.1 Overview

This section provides a detailed description of all memory and registers accessible to the end user.

### 20.7.2 Module Memory Map

**Table 20-1. Module Memory Map**

| Address | Use | Access |
|---|---|---|
| MBAR + 0x1300 | BDLC Control Register 1 (DLCBCR1) | R/W |
| MBAR + 0x1301 | BDLC State Vector Register (DLCBSVR) | R |
| MBAR + 0x1304 | BDLC Control Register 2 (DLCBCR2) | R/W |
| MBAR + 0x1305 | BDLC Data Register (DLCBDR) | R/W |
| MBAR + 0x1308 | BDLC Analog Round Trip Delay Register (DLCBARD) | R/W |
| MBAR + 0x1309 | BDLC Rate Select Register (DLCBRSR) | R/W |
| MBAR + 0x130C | BDLC Control Register (DLCSCR) | R/W |
| MBAR + 0x130D | BDLC Status Register (DLCBSTAT) | R |

## 20.7.3 Register Descriptions

### 20.7.3.1 BDLC Control Register 1 (DLCBCR1)

This register is used to configure and control the BDLC module.

Address MBAR + 0x1300

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | IMSG | CLKS | 0 | 0 | 0 | 0 | IE | WCM |
| W | | | | | | | | |
| Reset | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 20-3. BDLC Control Register 1**

**Table 20-2. BDLC Control Register 1 Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0 | IMSG | Ignore Message (Bit 7). This bit allows the CPU to ignore messages by disabling updates of the BDLC State Vector Register register until a new Start of Frame (SOF) or a BREAK symbol is detected. BDLC module transmitter and receiver operation are unaffected by the state of the IMSG bit.<br>1 Disable BDLC State Vector Register Updates. When set, all BDLC interrupt sources (exceptions are described below) will be prevented from updating BDLC State Vector Register status bits. Setting IMSG does not clear pending interrupt flags, the behavior of which will still be as described in Section , “BDLC State Vector Register (DLCBSVR)”. If this bit is set while the BDLC is receiving or transmitting a message, state vector register updates will be inhibited for the rest of the message.<br>0 Enable BDLC State Vector Register Updates. This bit is automatically cleared by the reception of a SOF symbol or a BREAK symbol. It will then allow updates of the state vector register to occur.<br>There are two situations in which interrupts will not be masked by the IMSG bit: when a wakeup interrupt occurs; and when a receiver error occurs which causes a byte pending transmission to be flushed from the transmit shadow register. See Section 20.7.3.4, “BDLC Data Register (DLCBDR)” for a description of the conditions which cause a pending transmission to be flushed. |
| 1 | CLKS | Clock Select (Bit 6). The nominal BDLC operating frequency (mux interface clock frequency - $f_{bdlc}$) **must** always be 1.048576 MHz or 1 MHz in order for J1850 bus communications to take place properly. The CLKS register bit is provided to allow the user to indicate to the BDLC module which frequency (1.048576 MHz or 1 MHz) is used so that each symbol time can be automatically adjusted.<br>The CLKS bit is a write once bit. All writes to this bit will be ignored after the first one.<br>Binary frequency (1.048576 MHz) is used for $f_{bdlc}$.<br>Integer frequency (1 MHz) is used. for $f_{bdlc}$<br>Section 20.8.1.3, “J1850 VPW Valid/Invalid Bits & Symbols” describes the transmitter and receiver VPW symbol timing for integer and binary frequencies. |

**Table 20-2. BDLC Control Register 1 Field Descriptions (continued)**

| Bits | Name | Description |
|---|---|---|
| 6 | IE | Interrupt Enable (Bit 1). This bit determines whether the BDLC module will generate CPU interrupt requests. It does not affect CPU interrupt requests when exiting the BDLC module Stop or Wait modes. Interrupt requests will be maintained until all of the interrupt request sources are cleared, by performing the specified actions upon the BDLC module's registers. Interrupts that were pending at the time that this bit is cleared may be lost.<br>1 Enable interrupt requests from BDLC module<br>0 Disable interrupt requests from BDLC module<br>If the programmer does not wish to use the interrupt capability of the BDLC module, the BDLC State Vector Register (BDLC State Vector Register) can be polled periodically by the programmer to determine BDLC module states. Refer to Section 20.7.3.2, "BDLC State Vector Register (DLCBSVR)" for a description of BDLC State Vector Register register and how to clear interrupt requests. |
| 7 | WCM | Wait Clock Mode (Bit 0) *(Provided CPU has Low Power Mode Options).* This bit determines how the BDLC module responds when the CPU enters WAIT mode. As described in Section 20.3, "Modes of Operation", the BDLC module can respond by either entering BDLC_STOP mode, where all internal clocks are stopped, or entering BDLC_WAIT mode where internal clocks are allowed to run.<br>1 Stop BDLC internal clocks during CPU wait mode (BDLC_STOP)<br>0 Run BDLC internal clocks during CPU wait mode (BDLC_WAIT) |

Read: Any time

Write: IMSG, IE, and WCM any time.

CLKS write once in normal and emulation modes.

CLKS bit has modified functionality in special test mode.

Writes to unimplemented bits 5-2 are ignored.

### 20.7.3.2 BDLC State Vector Register (DLCBSVR)

This register is provided to substantially decrease the CPU overhead associated with servicing interrupts while under operation of a MUX protocol. It provides a index offset that is directly related to the BDLC module's current state, which can be used with a user supplied jump table to rapidly enter an interrupt service routine. This eliminates the need for the user to maintain a duplicate state machine in software.

Address MBAR + 0x1301

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | 0 | 0 | I3 | I2 | I1 | I0 | 0 | 0 |
| W | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 20-4. BDLC State Vector Register**

Read: Any time

Write: Ignored

**Table 20-3. BDLC State Vector Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 2–5 | I[3:0] | Interrupt State Vector (Bits 5- 2). These bits indicate the source of the interrupt request that is currently pending. See Table 20-4.<br>The state encoding of the interrupt sources mean that only one interrupt source is dealt with at a time. Once the highest priority interrupt source is dealt with, if another interrupt event of a lower priority has also occurred, the value corresponding to that interrupt source appears in the BDLC State Vector Register. This continues until all BDLC interrupt sources have been dealt with and all bits in the BDLC State Vector Register are cleared.<br>• Wakeup — The BDLC has two different power-conserving modes, stop and wait. Wakeup from these modes is described below.<br>• Wakeup from BDLC Wait with CPU in Wait — If the CPU executes a WAIT instruction and the BDLC enters the BDLC wait mode, the clocks to the BDLC as well as the clocks in the MCU continue to run. The message which generates a Wake-up interrupt of the BDLC and the CPU will be received correctly.<br>• Wakeup from BDLC Stop with CPU in Wait — If the CPU executes a WAIT instruction and the BDLC enters the BDLC stop mode, the clocks to the BDLC are turned off, but the clocks in the MCU continue to run. The message which generates a Wake-up interrupt of the BDLC and the CPU will be received correctly. To ensure this, the EOF following the last message appearing on the bus must be received; otherwise, the message will not be received correctly.<br>• Wakeup from BDLC Stop with CPU in Stop — If the CPU executes a STOP all clocks to the BDLC as well as the clocks in the MCU are turned off including clocks to the BDLC. The message which generates a Wake-up interrupt of the BDLC and the CPU will not be received correctly.<br>• Symbol Invalid or Out of Range<br>• CRC Error — The Cyclical Redundancy Check Byte is used by the receiver(s) of each message to determine if any errors have occurred during the transmission of the message. If the message is not error free, the CRC error status is shown in the BDLC State Vector Register.<br>• Loss of Arbitration — The Loss of Arbitration status is entered when a loss of arbitration occurs while the BDLC is transmitting onto the bus.<br>• Tx Data Register Empty — The Tx Data Register Empty (TDRE) Byte is used to tell when data has been unloaded from the BDLC Data Register.<br>• Rx Data Register Full — The Rx Data Register Full (RDRF) Byte is used to tell when data has been loaded in the BDLC Data Register.<br>• Received IFR Byte — The BDLC can transmit and receive all four types of in-frame responses. As each byte of an IFR is received, the BDLC State Vector Register indicates this by setting this state.<br>• Received EOF — When a 280μs passive period on the bus is received, it signifies an EOF. Whenever this occurs, the EOF flag is set.<br>• No Interrupts Pending — This interrupt cannot generate an interrupt of the CPU. |

**Table 20-4. Interrupt Summary**

| BSVR | I3 | I2 | I1 | I0 | Interrupt Source | Priority |
|---|---|---|---|---|---|---|
| $00 | 0 | 0 | 0 | 0 | No Interrupts Pending | 0 (Lowest) |
| $04 | 0 | 0 | 0 | 1 | Received EOF | 1 |
| $08 | 0 | 0 | 1 | 0 | Received IFR byte | 2 |
| $0C | 0 | 0 | 1 | 1 | Rx data register full | 3 |
| $10 | 0 | 1 | 0 | 0 | Tx data register empty | 4 |
| $14 | 0 | 1 | 0 | 1 | Loss of arbitration | 5 |
| $18 | 0 | 1 | 1 | 0 | CRC error | 6 |
| $1C | 0 | 1 | 1 | 1 | Symbol invalid or out of range | 7 |
| $20 | 1 | 0 | 0 | 0 | Wakeup | 8 (Highest) |

### 20.7.3.3 BDLC Control Register 2 (DLCBCR2)

This register controls transmitter operations of the BDLC module.

Address MBAR + 0x1304

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | SMRST | DLOOP | 4XE | NBFS | TEOD | TSIFR | TMIFR1 | TMIFR0 |
| Reset | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 20-5. BDLC Control Register 2**

Read: any time

Write: any time

**Table 20-5. BDLC Control Register 2 Field Descriptions (Sheet 1 of 5)**

| Bits | Name | Description |
|---|---|---|
| 0 | SMRST | State Machine Reset (Bit 7). The programmer can use this bit to reset the BDLC state machines to an initial state after the user put the off-chip analog transceiver in loop back mode.<br>1 Setting SMRST arms the state machine reset generation logic. Setting SMRST does not affect BDLC module behavior in any way.<br>0 Clearing SMRST after it has been set will cause the generation of a state machine reset. After SMRST is cleared, the BDLC requires the bus to be idle for a minimum of an End of Frame symbol (EOF) time before allowing the reception of a message. The BDLC requires the bus to be idle for a minimum of an Inter-Frame Separator symbol (IFS) time before allowing any message to be transmitted. |
| 1 | DLOOP | Digital Loopback Mode (Bit 6). This bit determines the source to which the input of the digital filter is connected and can be used to isolate bus fault conditions. If a fault condition has been detected on the bus, this control bit allows the programmer to disconnect the digital filter from input from the receive pin (RXB) and connect it to the transmit output to the pin (TXB). In this configuration, data sent from the transmit buffer should be reflected back into the receive buffer. If no faults exist in the digital block, the fault is in the physical interface block or elsewhere on the J1850 bus.<br>1 When set, digital filter input is connected to the transmitter output. The BDLC module is now in Digital Loopback Mode of operation. The transmit pin (TXB) is driven low and not driven by the transmitter output.<br>0 When cleared, digital filter input is connected to receive pin (RXB) and the transmitter output is connected to the transmit pin (TXB). The BDLC module is taken out of Digital Loopback Mode and can now drive and receive from the J1850 bus normally. After writing DLOOP to zero, the BDLC module requires the bus to be idle for a minimum of an End of Frame symbol time before allowing a reception of a message. The BDLC module requires the bus to be idle for a minimum of an Inter-Frame Separator symbol time before allowing any message to be transmitted.<br>**Note:** The DLOOP bit is a fault condition aid and should never be altered after the BDLC Data Register is loaded for transmission. Changing DLOOP during a transmission may cause corrupted data to be transmitted onto the J1850 network. |

**Table 20-5. BDLC Control Register 2 Field Descriptions (Sheet 2 of 5)**

| Bits | Name | Description |
|---|---|---|
| 2 | 4X3 | 4X Mode Enable (Bit 5). This bit determines if the BDLC operates at normal transmit and receive speed (10.4 kbps) or in 4X Mode at 41.6 kbps. This feature is useful for fast download of data into a J1850 node for diagnostic or factory programming of the node.<br>1 When set, the BDLC module is put in 4X (41.6 kbps) operation.<br>0 When cleared, the BDLC module transmits and receives at 10.4 kbps. Reception of a BREAK symbol automatically clears this bit and sets the symbol invalid or out of range flag BDLC State Vector Register = $1C).<br>The effect of 4X receive operation on receive symbol timing boundaries is described in Section 20.8.1.3, “J1850 VPW Valid/Invalid Bits & Symbols”. |
| 3 | NBFS | Normalization Bit Format Select (Bit 4). This bit controls the format of the Normalization Bit (NB). SAE J1850 strongly encourages the use of an active long: ‘0’ for In-Frame Responses containing CRC and active short, ‘1’ for In-Frame Responses without CRC.<br>1 NB that is received or transmitted is a ‘0’ when the response part of an In-Frame Response (IFR) ends with a CRC byte. NB that is received or transmitted is a ‘1’ when the response part of an In-Frame Response (IFR) does not end with a CRC byte.<br>0 NB that is received or transmitted is a ‘1’ when the response part of an In-Frame Response (IFR) ends with a CRC byte. NB that is received or transmitted is a ‘0’ when the response part of an In-Frame Response (IFR) does not end with a CRC byte. |
| 4 | TEOD | Transmit End of Data (Bit 3). This bit is set by the programmer to indicate the end of a message being sent by the BDLC. It will append an 8-bit CRC after completing transmission of the current byte in the Tx Shift Register followed by the EOD symbol. If the transmit shadow register (refer to Section 20.8.3.1, “Protocol Architecture” for a description of the transmit shadow register) is full when TEOD is set, the CRC byte and EOD will be transmitted after the current byte in the Tx Shift Register and the byte in the Tx Shadow Register have been transmitted. Once TEOD is set, the transmit data register empty flag (TDRE) in the BDLC State Vector Register (BDLC State Vector Register) is cleared to allow lower priority interrupts to occur. This bit is also used to end an IFR. Bits TSIFR, TMIFR1, and TMIFR0 determine whether a CRC byte is appended before EOD transmission for IFRs.<br>1 Transmit EOD symbol.<br>0 The TEOD bit will be automatically cleared after the first CRC bit is sent, or if an error or loss of arbitration is detected on the bus. When TEOD is used to end an IFR transmission, TEOD is cleared when the BDLC receives back a valid EOD symbol, or an error condition or loss of arbitration occurs. |
| 5–7 | TSIFR, TMFR[1:0] | Transmit In-Frame Response Control (Bits 2-0). These three bits control the type of In-Frame Response being sent. The programmer should not set more than one of these control bits to a one at any given time. However, if more than one of these three control bits are set to one, the priority encoding logic will force the internal register bits to a known value as shown in the following table. But, when these bits are read, they will be the same as written earlier. For instance, if “011” is written to TSIFR, TMIFR1, TMIFR0, then internally, they’ll be encoded as “010”. However, when these bits are later read back, it’ll still be “011”. See Table 20-6.<br>The BDLC supports the In-frame Response (IFR) feature of J1850 by setting these bits correctly. The four types of J1850 IFR are shown in Figure 20-6. The purpose of the in-frame response modes is to allow single or multiple nodes to acknowledge receipt of the data by responding to a received message after they have seen the EOD symbol. For VPW modulation, the first bit of the IFR is always passive; therefore, an active normalization bit must be generated by the responder and sent prior to its ID/address byte. When there are multiple responders on the J1850 bus, only one normalization bit is sent which assists all other transmitting nodes to sync their responses. |

**Table 20-5. BDLC Control Register 2 Field Descriptions (Sheet 3 of 5)**

| Bits | Name | Description |
|---|---|---|
| 5 | TSIFR | Transmit Single Byte IFR with no CRC (Type 1 or 2). This bit is used to request the BDLC to transmit the byte in the BDLC Data Register as a single byte IFR with no CRC. Typically, the byte transmitted is a unique identifier or address of the transmitting (responding) node.<br>1 If this bit is set prior to a valid EOD being received with no CRC error, once the EOD symbol has been received the BDLC module will attempt to transmit the appropriate normalization bit followed by the byte in the BDLC Data Register.<br>0 The TSIFR bit will be automatically cleared once the EOD following one or more IFR bytes has been received or an error is detected on the bus.<br>The user must set the TSIFR bit before the EOF following the main part of the message frame is received, or no IFR transmit attempts will be made for the current message. If another node transmits an IFR to this message, the user must set the TSIFR bit before the normalization bit is received or no IFR transmit attempts will be made for the message. If another node does transmit a successful IFR or a reception error occurs, the TSIFR bit will be cleared. If not, the IFR will be transmitted after the EOD of the next received message.<br>If a loss of arbitration occurs when the BDLC module attempts transmission, after the IFR byte winning arbitration completes transmission, the BDLC module will again attempt to transmit the byte in the BDLC Data Register (with no normalization bit). The BDLC module will continue transmission attempts until an error is detected on the bus, or TEOD is set by the CPU, or the BDLC transmission is successful.<br>**Note:** Setting the TEOD bit before transmission of the IFR byte will direct the BDLC to make only one attempt at transmitting the byte.<br>If loss of arbitration occurs in the last bit of the IFR byte, two additional ‘1’ bits **will not** be sent out because the BDLC will attempt to retransmit the byte in the transmit shift register after the IFR byte winning arbitration completes transmission. |

**Table 20-5. BDLC Control Register 2 Field Descriptions (Sheet 4 of 5)**

| Bits | Name | Description |
|---|---|---|
| 6 | TMIFR1 | Transmit Multiple Byte IFR with CRC (Type 3). This bit requests the BDLC module to transmit the byte in the BDLC Data Register (BDLC Data Register) as the first byte of a multiple byte IFR with CRC or as a single byte IFR with CRC.Response IFR bytes are still subject to J1850 message length maximums.<br>1 If this bit is set prior to a valid EOD being received with no CRC error, once the EOD symbol has been received, the BDLC module will attempt to transmit the appropriate normalization bit followed by IFR bytes.The programmer should set TEOD after the last IFR byte has been written into BDLC Data Register. After TEOD has been set and the last IFR byte has been transmitted, the CRC byte is transmitted.<br>0 The TMIFR1 bit will be automatically cleared once the BDLC module has successfully transmitted the CRC byte and EOD symbol, by the detection of an error on the multiplex bus, a transmitter underrun, or loss of arbitration.<br>After the byte in the BDLC Data Register has been loaded into the transmit shift register, the TDRE flag will be set in the BDLC State Vector Register register, similar to the main message transmit sequence. If the interrupt enable bit (IE in BDLC Control Register 1) is set, an interrupt request from the BDLC module is generated.The programmer should then load the next byte of the IFR into the BDLC Data Register for transmission. When the last byte of the IFR has been loaded into the BDLC Data Register, the programmer should set the TEOD bit in the BDLC control register 2. This will instruct the BDLC module to transmit a CRC byte once the byte in the BDLC Data Register is transmitted, and then transmit an EOD symbol, indicating the end of the IFR portion of the message frame.<br>However, if the programmer wishes to transmit a single byte followed by a CRC byte, the programmer should load the byte into the BDLC Data Register and then set the TMIFR1 bit before the EOD symbol has been received. Once the TDRE flag is set and interrupt occurs (if enabled), the programmer should then set the TEOD bit in BDLC Control Register 2. This will result in the byte in the BDLC Data Register being the only byte transmitted before the IFR CRC byte.<br>The user must set the TMIFR1 bit before the EOF following the main part of the message frame is received, or no IFR transmit attempts will be made for the current message. If another node transmits an IFR to this message, the user must set the TMIFR1 bit before the normalization bit is received or no IFR transmit attempts will be made for the message. If another node does transmit a successful IFR or a reception error occurs, the TMIFR1 bit will be cleared. If not, the IFR will be transmitted after the EOD of the next received message.<br>If a transmitter underrun error occurs during transmission (caused by the programmer not writing another byte to the BDLC Data Register following the TDRE flag being set) the BDLC module will automatically disable the transmitter after the byte currently in the shifter plus two extra 1-bits have been transmitted. The receiver will pick this up as an framing error and relay it in the State Vector Register as an invalid symbol error. The TMIFR1 bit will also be cleared.<br>If a loss of arbitration occurs when the BDLC module is transmitting a multiple byte IFR with CRC, the BDLC module will go to the loss of arbitration state, set the appropriate flag and cease transmission. The TMIFR1 bit will be cleared and no attempt will be made to retransmit the byte in the BDLC Data Register. If loss of arbitration occurs in the last bit of the IFR byte, two additional one bits (a passive long followed by an active short) **will** be sent out.<br>**Note:** The extra logic 1s are an enhancement to the J1850 protocol which forces a byte boundary condition fault. This is helpful in preventing noise on the J1850 bus from corrupting a message. |

**Table 20-5. BDLC Control Register 2 Field Descriptions (Sheet 5 of 5)**

| Bits | Name | Description |
|---|---|---|
| 7 | TMIFR0 | Transmit Multiple Byte IFR with no CRC (Type 3). This bit is used to request the BDLC module to transmit the byte in the BDLC Data Register as the first byte of a multiple byte IFR without CRC. Response IFR bytes are still subject to J1850 message length maximums.<br>1 If this bit is set prior to a valid EOD being received with no CRC error, once the EOD symbol has been received the BDLC module will attempt to transmit the appropriate normalization bit followed by IFR bytes. The programmer should set TEOD after the last IFR byte has been written into BDLC Data Register. After TEOD has been set, the last IFR byte to be transmitted will be the last byte which was written into the BDLC Data Register.<br>0 The TMIFR0 bit will be automatically cleared once the BDLC module has successfully transmitted the EOD symbol, by the detection of an error on the multiplex bus, a transmitter underrun, or loss of arbitration.<br>After the byte in the BDLC Data Register has been loaded into the transmit shift register, the TDRE flag will be set in the BDLC State Vector Register register, similar to the main message transmit sequence. If the interrupt enable bit (IE in BDLC Control Register 1) is set, an interrupt request from the BDLC module is generated. The programmer should then load the next byte of the IFR into the BDLC Data Register for transmission. When the last byte of the IFR has been loaded into the BDLC Data Register, the programmer should set the TEOD bit in the BDLC Control Register 2. This will instruct the BDLC to transmit an EOD symbol, indicating the end of the IFR portion of the message frame. The BDLC module will not append a CRC.<br>However, if the programmer wishes to transmit a single byte, the programmer should load the byte into the BDLC Data Register and then set the TMIFR0 bit before the EOD symbol has been received. Once the TDRE flag is set and interrupt occurs (if enabled), the programmer should then set the TEOD bit in BDLC Control Register 2. This will result in the byte in the BDLC Data Register being the only byte transmitted.<br>The user must set the TMIFR0 bit before the EOF following the main part of the message frame is received, or no IFR transmit attempts will be made for the current message. If another node transmits an IFR to this message, the user must set the TMIFR0 bit before the normalization bit is received or no IFR transmit attempts will be made for the message. If another node does transmit a successful IFR or a reception error occurs, the TMIFR0 bit will be cleared. If not, the IFR will be transmitted after the EOD of the next received message.<br>If a transmitter underrun error occurs during transmission (caused by the programmer not writing another byte to the BDLC Data Register following the TDRE flag being set) the BDLC module will automatically disable the transmitter after the byte currently in the shifter plus two extra 1-bits have been transmitted. The receiver will pick this up as an framing error and relay it in the State Vector Register as an invalid symbol error. The TMIFR0 bit will also be cleared.<br>If a loss of arbitration occurs when the BDLC module is transmitting a multiple byte IFR without CRC, the BDLC module will go to the loss of arbitration state, set the appropriate flag and cease transmission. The TMIFR0 bit will be cleared and no attempt will be made to retransmit the byte in the BDLC Data Register. If loss of arbitration occurs in the last bit of the IFR byte, two additional one bits (a passive long followed by an active short) **will** be sent out.<br>**Note:** The extra logic 1s are an enhancement to the J1850 protocol which forces a byte boundary condition fault. This is helpful in preventing noise on the J1850 bus from corrupting a message. |

**Table 20-6. Transmit In-Frame Response Control Bit Priority Encoding**

| WRITE | | | READ | | | ACTUAL (Internal Register) | | |
|---|---|---|---|---|---|---|---|---|
| TSIFR | TMIFR1 | TMIFR0 | TSIFR | TMIFR1 | TMIFR0 | TSIFR | TMIFR1 | TMIFR0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | X | X | 1 | X | X | 1 | 0 | 0 |
| 0 | 1 | X | 0 | 1 | X | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |

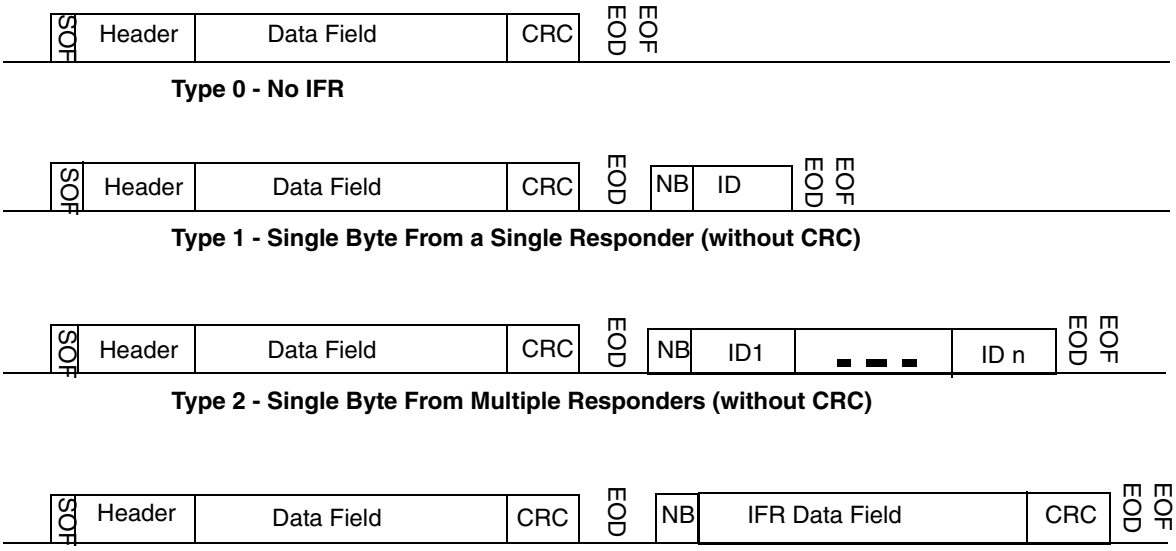



**Figure 20-6. Types of In-Frame Response**

### 20.7.3.4 BDLC Data Register (DLCBDR)

This register is used to pass the data to be transmitted to the J1850 bus from the CPU to the BDLC module. It is also used to pass data received from the J1850 bus to the CPU.

Address MBAR + 0x1305

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| Reset | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 20-7. BDLC Data Register**

Read: any time

Write: any time

**Table 20-7. BDLC Data Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0–7 | D7:D0 | Receive/Transmit Data (Bits 7–0). While transmitting, each data byte (after the first one) should be written only after a “Tx Data Register Empty” (TDRE) interrupt has occurred, or the BDLC State Vector Register register has been polled indicating this condition.<br>Data read from this register will be the last data byte received from the J1850 bus. This received data should only be read after a “Rx Data Register Full” (RDRF) or “Received IFR byte” (RXIFR) interrupt has occurred or the BDLC State Vector Register register has been polled indicating either of these two conditions.<br>The BDLC Data Register is double buffered via a transmit shadow register and a receive shadow register. After the byte in the transmit shift register has been transmitted, the byte currently stored in the transmit shadow register is loaded into the transmit shift register. Once the transmit shift register has shifted the first bit out, the TDRE flag is set, and the shadow register is ready to accept the next byte of data.<br>The receive shadow register works similarly. Once a complete byte has been received, the receive shift register stores the newly received byte into the receive shadow register. The RDRF flag (or RXIFR flag if the received byte is part of an IFR) is set to indicate that a new byte of data has been received. The programmer has one BDLC module byte reception time to read the shadow register and clear the RDRF or RXIFR flag before the shadow register is overwritten by the newly received byte.<br>If the user writes the first byte of a message to be transmitted to the BDLC Data Register and then determines that a different message should be transmitted, the user can write a new byte to the BDLC Data Register up until the transmission begins.This new byte will replace the original byte in the BDLC Data Register.<br>From the time a byte is written to the BDLC Data Register until it is transferred to the transmit shift register, the transmit shadow register is considered full and the byte pending transmission. If one of the IFR transmission control bits (TSIFR, TMIFR1, or TMIFR0 in BDLC Control Register 2) is also set, the byte is pending transmission as an IFR. A byte pending transmission will be flushed from the transmit shadow register and the transmission canceled if one of the following occurs: a loss of arbitration or transmitter error on the byte currently being transmitted; a symbol error, framing error, bus fault, or BREAK symbol is received. If the byte pending transmission is an IFR byte, the reception of a message with a CRC error will also cause the byte in the transmit shadow register to be flushed.<br>To abort an in-progress transmission, the programmer should simply stop loading more data into the BDLC Data Register. This will cause a transmitter underrun error and the BDLC module will automatically disable the transmitter on the next non-byte boundary. This means that the earliest a transmission can be halted is after at least one byte (plus two extra 1-bits) has been transmitted. The receiver will pick this up as an error and relay it in the State Vector Register as an invalid symbol error. |

### 20.7.3.5 BDLC Analog Round Trip Delay Register (DLCBARD)

This register is used to program the BDLC module so that it compensates for the round trip delays of different external transceivers. Also the polarity of the receive pin (RXB) is set in this register.

Address MBAR + 0x1308

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | 0 | RXPOL | 0 | BO4 | BO3 | BO2 | BO1 | BO0 |
| W | | | | | | | | |
| Reset | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |

**Figure 20-8. BDLC Analog Round Trip Delay Register**

Read: any time

Write: write once in normal and emulation modes.

Register functionality modified in special test mode.

Writes to unimplemented bits 7, 5 are ignored.

**Table 20-8. BDLCAnalog Round Trip Delay Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 1 | RXPOL | Receive Pin Polarity (Bit 6). The Receive pin Polarity bit is used to select the polarity of incoming signal on the receive pin. Some external analog transceiver inverts the receive signal from the J1850 bus before feeding back to the digital receive pin.<br>1 Select normal/true polarity; true non-inverted signal from J1850 bus, i.e., the external transceiver does not invert the receive signal.<br>0 Select inverted polarity, where external transceiver inverts the receive signal. |
| 3–0 | BO[4:0] | BDLC Analog Roundtrip Delay Offset Field (Bits 4-0). BO[4:0] adjust the transmitted symbol timings to account for the differing roundtrip delays found in different SAE J1850 analog transceivers. The allowable delay range is from 0 μs to 31 μs, with a nominal target of 16 μs (reset value). Refer to Table 20-9 for the BO[4:0] values corresponding to the expected transceiver delays and the resultant transmitter timing adjustment (in mux interface clock periods ($t_{bdlc}$)). Refer to the analog transceiver device specification for the expected roundtrip delay through both the transmitter and the receiver. The sum of these two delays makes up the total roundtrip delay value.<br>**Note:** For Digital Loopback test, the Analog Roundtrip Delay Offset Field should be set to 0μs. |

**Table 20-9. BARD Values vs. Transceiver Delay and Transmitter Timing Adjustment**

| BARD Offset Bits BO[4:0] | Corresponding Expected Transceiver's delays (μs) | Transmitter Symbol Timing Adjustment ($t_{bdlc}$)[1] |
|---|---|---|
| 00000 | 0 | 0 |
| 00001 | 1 | 1 |
| 00010 | 2 | 2 |
| 00011 | 3 | 3 |
| 00100 | 4 | 4 |
| 00101 | 5 | 5 |
| 00110 | 6 | 6 |
| 00111 | 7 | 7 |
| 01000 | 8 | 8 |
| 01001 | 9 | 9 |
| 01010 | 10 | 10 |
| 01011 | 11 | 11 |
| 01100 | 12 | 12 |
| 01101 | 13 | 13 |
| 01110 | 14 | 14 |
| 01111 | 15 | 15 |
| 10000 | 16 | 16 |
| 10001 | 17 | 17 |
| 10010 | 18 | 18 |
| 10011 | 19 | 19 |
| 10100 | 20 | 20 |
| 10101 | 21 | 21 |
| 10110 | 22 | 22 |
| 10111 | 23 | 23 |
| 11000 | 24 | 24 |
| 11001 | 25 | 25 |
| 11010 | 26 | 26 |
| 11011 | 27 | 27 |
| 11100 | 28 | 28 |
| 11101 | 29 | 29 |
| 11110 | 30 | 30 |
| 11111 | 31 | 31 |

**Note:**

1. The transmitter symbol timing adjustment is the same for binary and integer bus frequencies.

### 20.7.3.6 BDLC Rate Select Register (DLCBRSR)

This register determines the divider prescaler value for the mux interface clock ($f_{bdlc}$). Only integer multiple of the 1 MHz or 1.048576 MHz $f_{bdlc}$ are supported as input clock.

Address MBAR + 0x1309

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R<br>W | R7 | R6 | R5 | R4 | R3 | R2 | R1 | R0 |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 20-9. BDLC Rate Select Register**

Read: any time

Write: write once in normal and emulation modes.

**Table 20-10. BDLC Rate Select RegisterField Descriptions**

| Bits | Name | Description |
|---|---|---|
| 0–7 | R[7:0] | Rate Select (Bits 7-0). These bits determine the amount by which the frequency of the system clock signal is divided to generate the MUX Interface clock ($f_{bdlc}$) which defines the basic timing resolution of the MUX Interface. The value programmed into these bits is dependent on the chosen system clock frequency. See Table 20-11 and Table 20-12 for example rate selects for different bus frequencies. All divisor values from divide by 1 to divide by 256 are possible, but are not shown in the tables.<br>**Note:** Although the maximum divider is 256, a divider which will generate a 1 MHz or 1.048576 MHz $f_{bdlc}$ must be selected in order for J1850 communications to occur. |

**Table 20-11. BDLC Rate Selection for Binary Frequencies [CLKS = 1]**

| IP Bus Clock Frequency | R[7:0] | Division | $f_{bdlc}$ |
|---|---|---|---|
| $f_{CLOCK}$=1.048576 MHz | $00 | 1 | 1.048576 MHz |

**Table 20-12. BDLC Rate Selection for Integer Frequencies [CLKS = 0]**

| IP Bus Clock Frequency | R[7:0] | Division | $f_{bdlc}$ |
|---|---|---|---|
| $f_{CLOCK}$=132.00000 MHz | $83 | 132 | 1.000000 MHz |
| $f_{CLOCK}$=66.00000 MHz | $41 | 66 | 1.000000 MHz |
| $f_{CLOCK}$=54.00000 MHz | $35 | 54 | 1.000000 MHz |
| $f_{CLOCK}$=33.00000 MHz | $20 | 33 | 1.000000 MHz |
| $f_{CLOCK}$=27.00000 MHz | $1A | 27 | 1.000000 MHz |

### 20.7.3.7 BDLC Control Register (DLCSCR)

The following register enables the BLDC module.

Address MBAR + 0x130C

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | 0 | 0 | 0 | BDLCE | 0 | 0 | 0 | BREAK |
| W | | | | | | | | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 20-10. BDLC Control Register**

Read: any time

Write: any time

**Table 20-13. BDLC Control Register 2 Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 3 | BDLCE | BDLC Enable (Bit 4). This bit serves as a mux interface clock ($f_{bdlc}$) enable/disable for power savings.<br>1 The mux interface clock ($f_{bdlc}$) and BDLC module are enabled to allow J1850 communications to take place.<br>0 The mux interface clock ($f_{bdlc}$) is disabled, shutting down the BDLC module for power saving. Bus clocks are still running allowing registers to be accessed. |
| 7 | BREAK | Send BREAK signal (Bit 0). This bit determines whether the BDLC module will generate a BREAK symbol.<br>1 The BDLC module will immediately send a Break signal on the bus, regardless of its current transmit or receive status.<br>0 The BDLC module does not generate a BREAK symbol.<br>After setting the BREAK bit it will automatically be cleared after two IPB clock cycles.<br>The active Break signal causes any other transmitting module to stop transmitting immediately because it loses arbitration. It is at least 280 μs long.<br>When the BDLC is operating at the high bus speed all 4X symbol times are one fourth that shown, except for Break, which will be transmitted the same length in 1X or 4X mode. |

### 20.7.3.8 BDLC Status Register (DLCBSTAT)

This register Indicates the status of the BLDC module.

Address MBAR + 0x130D

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | IDLE |
| W | Unimplemented | | | | | Reserved | Unimplemented | |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 20-11. BDLC Status Register**

Read: any time

Write: ignored in normal and emulation modes

Register functionality is modified in special test mode.

**Table 20-14. BDLC Status Register Field Descriptions**

| Bits | Name | Description |
|---|---|---|
| 7 | IDLE | IDLE Idle (Bit 7). This bit indicates when the BDLC module is idle.<br>1 BDLC module has received IFS and no data is being transmitted or received.<br>0 BDLC module is either transmitting or receiving data.<br>**Note:** BDLC module is only idle after receiving IFS. The IDLE bit is 0 during reset since the BDLC module needs to wait for an IFS before becoming idle. Noise on the bus will be filtered and the IDLE bit will remain unchanged. |

# 20.8 Functional Description

## 20.8.1 General

The BDLC module is a serial communication module which allows the user to send and receive messages across a Society of Automotive Engineers (SAE) J1850 serial communication network. The user's software handles each transmitted or received message on a byte-by-byte basis, while the BDLC performs all of the network access, arbitration, message framing and error detection duties.

### 20.8.1.1 J1850 Frame Format

As noted above and in Section 20.2, "Features", the BDLC module communicates across an SAE J1850 network. As such, all messages transmitted on the J1850 bus are structured using the format below. The following sections describe this format and it's meanings.

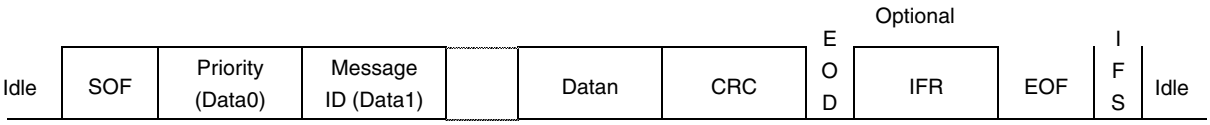



**Figure 20-12. J1850 Bus Message Format (VPW)**

SAE J1850 states that each message has a maximum length of 101 bit times or 12 bytes (excluding SOF, EOD, NB and EOF).

- SOF — Start of Frame Symbol

  All messages transmitted onto the J1850 bus must begin with an long active SOF symbol. This indicates to any listeners on the J1850 bus the start of a new message transmission. The SOF symbol is not used in the CRC calculation.

- Data — In Message Data Bytes

  The data bytes contained in the message include the message priority/type, message I.D. byte, and any actual data being transmitted to the receiving node. See SAE J1850 - Class B Data Communications Network Interface, for more information about 1 and 3 Byte Headers.

  Messages transmitted by the BDLC module onto the J1850 bus must contain at least one data byte, and therefore can be as short as one data byte and one CRC byte. Each data byte in the message is 8 bits in length, transmitted MSB to LSB.

- CRC — Cyclical Redundancy Check Byte

  This byte is used by the receiver(s) of each message to determine if any errors have occurred during the transmission of the message. The BDLC calculates the CRC byte and appends it onto any messages transmitted onto the J1850 bus, and also performs CRC detection on any messages it receives from the J1850 bus.

  CRC generation uses the divisor polynomial $X^8+X^4+X^3+X^2+1$. The remainder polynomial is initially set to all ones, and then each byte in the message after the SOF symbol is serially processed through the CRC generation circuitry. The one's complement of the remainder then becomes the 8-bit CRC byte, which is appended to the message after the data bytes, in MSB to LSB order.

  When receiving a message, the BDLC uses the same divisor polynomial. All data bytes, excluding the SOF and EOD symbols, but including the CRC byte, are used to check the CRC. If the message

is error free, the remainder polynomial will equal $X^7+X^6+X^2$ ($C4), regardless of the data contained in the message. If the calculated CRC does not equal $C4, the BDLC will recognize this as a CRC error and set the CRC error flag in the BDLC State Vector Register.

- EOD — End of Data Symbol

  The EOD symbol is a long passive period on the J1850 bus used to signify to any recipients of a message that the transmission by the originator has completed. No flag is set upon reception of the EOD symbol.

- IFR — In Frame Response Bytes

  The IFR section of the J1850 message format is optional. Users desiring further definition of in-frame response should review the “SAE J1850 Class B Data Communications Network Interface” specification.

- EOF — End of Frame Symbol

  This symbol is a passive period on the J1850 bus, longer than an EOD symbol, which signifies the end of a message. Since an EOF symbol is longer than an EOD symbol, if no response is transmitted after an EOD symbol, it becomes an EOF, and the message is assumed to be completed. The EOF flag is set upon receiving the EOF symbol.

- IFS — Inter-Frame Separation Symbol

  The IFS symbol is a passive period on the J1850 bus which allows proper synchronization between nodes during continuous message transmission. The IFS symbol is transmitted by a node following the completion of the EOF period.

  When the last byte of a message has been transmitted onto the J1850 bus, and the EOF symbol time has expired, all nodes must then wait for the IFS symbol time to expire before transmitting an SOF, marking the beginning of another message.

  However, if the BDLC module is waiting for the IFS period to expire before beginning a transmission and a rising edge is detected before the IFS time has expired, it will internally synchronize to that edge.

  A rising edge may occur during the IFS period because of varying clock tolerances and loading of the J1850 bus, causing different nodes to observe the completion of the IFS period at different times. Receivers must synchronize to any SOF occurring during an IFS period to allow for individual clock tolerances.

- Break

  If the BDLC module is transmitting at the time a BREAK is detected, it treats the BREAK as if a transmission error had occurred, and halts transmission.The BDLC module can transmit a BREAK symbol. If while receiving a message the BDLC module detects a BREAK symbol, it treats the BREAK as a reception error and sets the invalid symbol flag. If while receiving a message in 4X mode, the BDLC module detects a BREAK symbol, it treats the BREAK as a reception error, sets BDLC State Vector Register register to $1C, and exits 4X mode.The 4XE bit in BDLC Control Register 2 is automatically cleared upon reception of the BREAK symbol.

- Idle Bus

  An idle condition exists on the bus during any passive period after expiration of the IFS period. Any node sensing an idle bus condition can begin transmission immediately.

### 20.8.1.2 J1850 VPW Symbols

Variable Pulse Width modulation (VPW) is an encoding technique in which each bit is defined by the time between successive transitions, and by the level of the bus between transitions, active or passive. Active and passive bits are used alternately. This encoding technique is used to reduced the number of bus transitions for a given bit rate. See Section 20.2, “Features”.

The symbol values shown below are nominal values. Refer to the electrical specification for a more complete description of symbol values. Each logic one or logic zero contains a single transition, and can be at either the active or passive level and one of two lengths, either 64µs or 128µs ($T_{NOM}$ at 10.4kbps baud rate), depending upon the encoding of the previous bit. The SOF, EOD, EOF and IFS symbols will always be encoded at an assigned level and length. See Figure 20-13.

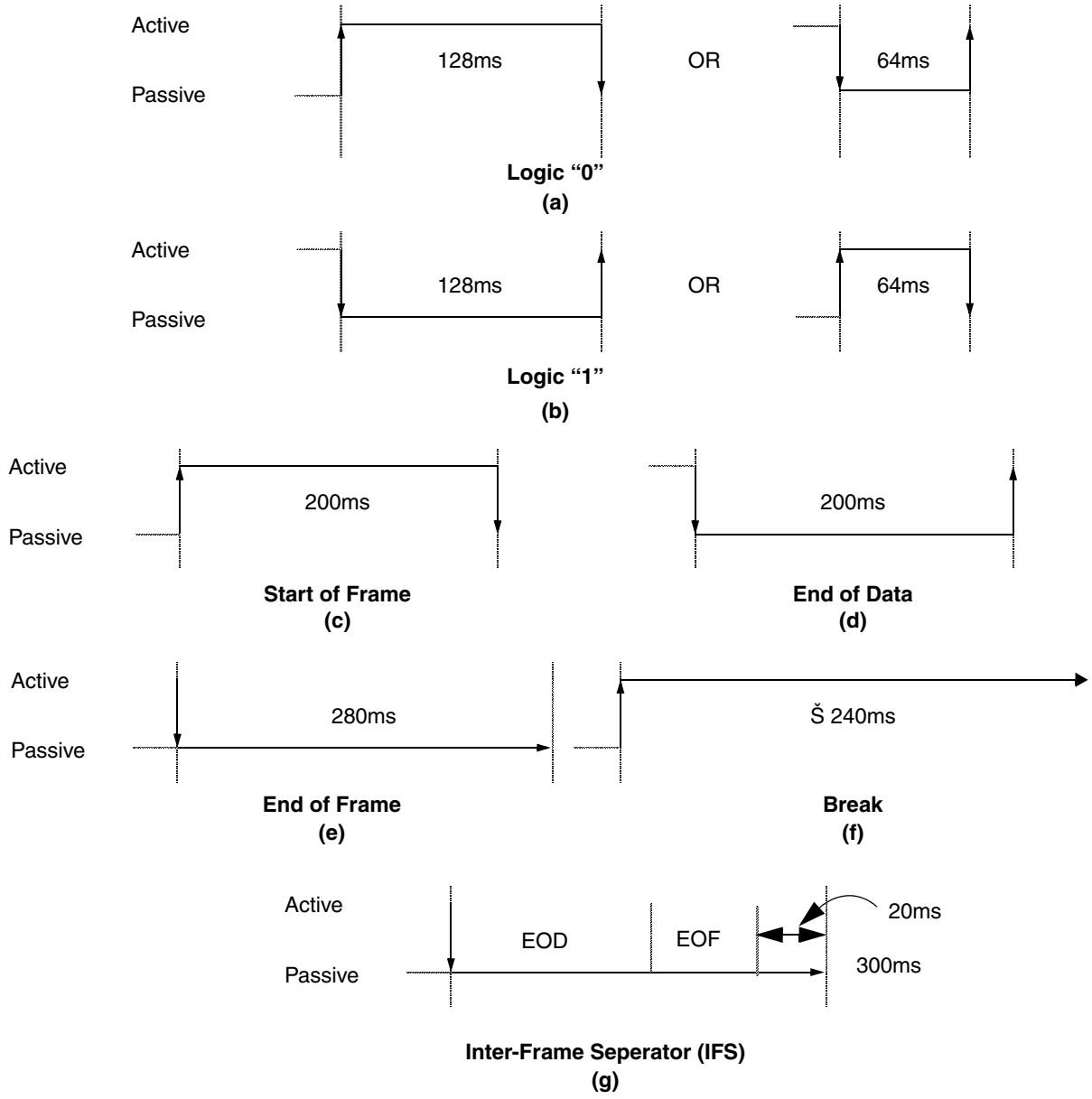



**Figure 20-13. J1850 VPW Symbols**

Each message will begin with an SOF symbol, an active symbol, and therefore each data byte (including the CRC byte) will begin with a passive bit, regardless of whether it is a logic one or a logic zero. All VPW bit lengths stated in the following descriptions are typical values at a 10.4kbps bit rate.

- Logic “0”

  A logic zero is defined as either an active to passive transition followed by a passive period 64µs in length, or a passive to active transition followed by an active period 128µs in length (Figure 20-13(a)).
- Logic “1”

  A logic one is defined as either an active to passive transition followed by a passive period 128µs in length, or a passive to active transition followed by an active period 64µs in length (Figure 20-13(b)).
- NB — Normalization Bit

  The NB symbol has the same property as a logic “1” or a logic “0”.It is only used in IFR message responses. This bit is defined as an active bit.
- SOF — Start of Frame Symbol

  The SOF symbol is defined as passive to active transition followed by an active period 200µs in length (Figure 20-13(c)). This allows the data bytes which follow the SOF symbol to begin with a passive bit, regardless of whether it is a logic one or a logic zero.
- EOD — End of Data Symbol

  The EOD symbol is defined as an active to passive transition followed by a passive period 200µs in length (Figure 20-13(d)).
- EOF — End of Frame Symbol

  The EOF symbol is defined as an active to passive transition followed by a passive period 280µs in length (Figure 20-13(e)). If there is no IFR byte transmitted after an EOD symbol is transmitted, after another 80µs the EOD becomes an EOF, indicating the completion of the message.
- IFS — Inter-Frame Separation Symbol

  The IFS symbol is defined as a passive period 300µs in length. The IFS symbol contains no transition, since when used it always follows an EOF symbol.(Figure 20-13(g))
- BREAK — Break Signal

  The BREAK signal is defined as a passive to active transition followed by an active period of at least 240µs (Figure 20-13(f)).
- IDLE

  An IDLE is defined as a passive period greater than 300µs in length.

### 20.8.1.3 J1850 VPW Valid/Invalid Bits & Symbols

The timing tolerances for receiving data bits and symbols from the J1850 bus have been defined to allow for variations in oscillator frequencies. In many cases the maximum time allowed to define a data bit or symbol is equal to the minimum time allowed to define another data bit or symbol.

Since the minimum resolution of the BDLC module for determining what symbol is being received is equal to a single period of the MUX Interface clock, ($t_{bdlc}$). i.e. the receiver symbol timing boundaries are subject to an uncertainty of 1 $t_{bdlc}$ due to sampling considerations.

This clock resolution of 1 $t_{bdlc}$ allows the BDLC module to properly differentiate between the different bits and symbols, without reducing the valid window for receiving bits and symbols from transmitters onto the J1850 bus having varying oscillator frequencies.

- Transmit and Receive Symbol Timing Specifications

  Table 20-15 through Table 20-20 contain the SAE J1850 transmit and receive symbol timing specifications for the BDLC module. The units used in these tables are mux interface clock periods ($t_{bdlc}$). The mux interface clock is a divided down version of the bus clock input to the module (see Section 20.7.3.6, “BDLC Rate Select Register (DLCBRSR)”). The mux interface clock drives the transmit and receive counters which control symbol generation and identification. The symbol timing in effect during J1850 operations is dependent the state of two control bits: the CLKS bit BDLC Control Register 1, which indicates whether the bus clock is an integer frequency or a binary frequency; the 4XE bit in BDLC Control Register 2, which is used to select 4X operation.

  Table 20-15 and Table 20-17 indicate the transmit and receive timing for integer bus frequencies (CLKS = 0) and 4X operation disabled (4XE = 0). It is assumed that for integer bus frequencies the divided down mux interface clock frequency will be 1MHz ($t_{bdlc}$ = 1 µs).

  Table 20-16 and Table 20-18 indicated the transmit and receive timing for binary bus frequencies (CLKS = 1) and 4X operation disabled (4XE = 0). It is assumed that for binary bus frequencies the divided down mux interface clock frequency will be 1.048576 MHz ($t_{bdlc}$ = 0.953674 µs). The symbol timing values are adjusted to compensate for the shortening of the mux interface clock period.

  Table 20-19 and Table 20-20 show how the receive symbol timing values are adjusted when 4X operation is enabled (4XE = 1) for both integer bus frequencies (CLKS = 0) and binary bus frequencies (CLKS = 1), respectively.

  The values specified in the tables are for the symbols appearing on the SAE J1850 bus. These values assume the BDLC module is communicating on the SAE J1850 bus using an external analog transceiver, and that the BDLC module analog roundtrip delay value programed into the BDLC Analog Round Trip Delay Register register is the appropriate value for the transceiver being used. If these conditions are not met, the symbol timings being measured on the SAE J1850 bus will be significantly affected. For a detailed description of how symbol timings are measured on the SAE J1850 bus, refer to the appropriate SAE documents.

**Table 20-15. BDLC Transmitter VPW Symbol Timing for Integer Frequencies**

| Number | Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| 1 | Passive Logic 0 | $T_{tvp1}$ | 62 | 64 | 66 | $t_{bdlc}$ |
| 2 | Passive Logic 1 | $T_{tvp2}$ | 126 | 128 | 130 | $t_{bdlc}$ |

**Table 20-15. BDLC Transmitter VPW Symbol Timing for Integer Frequencies (continued)**

| Number | Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| 3 | Active Logic 0 | $T_{tva1}$ | 126 | 128 | 130 | $t_{bdlc}$ |
| 4 | Active Logic 1 | $T_{tva2}$ | 62 | 64 | 66 | $t_{bdlc}$ |
| 5 | Start of Frame (SOF) | $T_{tva3}$ | 198 | 200 | 202 | $t_{bdlc}$ |
| 6 | End of Data (EOD)[1] | $T_{tvp3}$ | 162 | 164 | 166 | $t_{bdlc}$ |
| 7 | End of Frame (EOF)[1] | $T_{tv4}$ | 238 | 240 | 242 | $t_{bdlc}$ |
| 8 | Inter-Frame Separator (IFS)[1] | $T_{tv5}$ | 298 | 300 | 302 | $t_{bdlc}$ |

**Note:**

1. The transmitter timing for this symbol depends upon the minimum detection time of the symbol by the receiver.

**Table 20-16. BDLC Transmitter VPW Symbol Timing for Binary Frequencies**

| Number | Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| 1 | Passive Logic 0 | $T_{tvp1}$ | 65 | 67 | 69 | $t_{bdlc}$ |
| 2 | Passive Logic 1 | $T_{tvp2}$ | 132 | 134 | 136 | $t_{bdlc}$ |
| 3 | Active Logic 0 | $T_{tva1}$ | 132 | 134 | 136 | $t_{bdlc}$ |
| 4 | Active Logic 1 | $T_{tva2}$ | 65 | 67 | 69 | $t_{bdlc}$ |
| 5 | Start of Frame (SOF) | $T_{tva3}$ | 208 | 210 | 212 | $t_{bdlc}$ |
| 6 | End of Data (EOD)[1] | $T_{tvp3}$ | 170 | 172 | 174 | $t_{bdlc}$ |
| 7 | End of Frame (EOF)[1] | $T_{tv4}$ | 250 | 252 | 254 | $t_{bdlc}$ |
| 8 | Inter-Frame Separator (IFS)[1] | $T_{tv5}$ | 313 | 315 | 317 | $t_{bdlc}$ |

**Note:**

1. The transmitter timing for this symbol depends upon the minimum detection time of the symbol by the receiver.

**Table 20-17. BDLC Receiver VPW Symbol Timing for Integer Frequencies**

| Number | Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| 1 | Passive Logic 0 | $T_{rvp1}$ | 32 | 64 | 95 | $t_{bdlc}$ |
| 2 | Passive Logic 1 | $T_{rvp2}$ | 96 | 128 | 163 | $t_{bdlc}$ |
| 3 | Active Logic 0 | $T_{rva1}$ | 96 | 128 | 163 | $t_{bdlc}$ |
| 4 | Active Logic 1 | $T_{rva2}$ | 32 | 64 | 95 | $t_{bdlc}$ |
| 5 | Start of Frame (SOF) | $T_{rva3}$ | 164 | 200 | 239 | $t_{bdlc}$ |
| 6 | End of Data (EOD) | $T_{rvp3}$ | 164 | 200 | 239 | $t_{bdlc}$ |
| 7 | End of Frame (EOF) | $T_{rv4}$ | 240 | 280 | 299 | $t_{bdlc}$ |
| 8 | Inter-Frame Separator (IFS) | $T_{rv5}$ | 281 | — | — | $t_{bdlc}$ |
| 9 | Break Signal (BREAK) | $T_{rv6}$ | 240 | — | — | $t_{bdlc}$ |

**Note:**

1. The receiver symbol timing boundaries are subject to an uncertainty of 1 $t_{bdlc}$ due to sampling considerations.

**Table 20-18. BDLC Receiver VPW Symbol Timing for Binary Frequencies**

| Number | Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| 1 | Passive Logic 0 | $T_{rvp1}$ | 34 | 67 | 100 | $t_{bdlc}$ |
| 2 | Passive Logic 1 | $T_{rvp2}$ | 101 | 134 | 171 | $t_{bdlc}$ |
| 3 | Active Logic 0 | $T_{rva1}$ | 101 | 134 | 171 | $t_{bdlc}$ |
| 4 | Active Logic 1 | $T_{rva2}$ | 34 | 67 | 100 | $t_{bdlc}$ |
| 5 | Start of Frame (SOF) | $T_{rva3}$ | 172 | 210 | 251 | $t_{bdlc}$ |
| 6 | End of Data (EOD) | $T_{rvp3}$ | 172 | 210 | 251 | $t_{bdlc}$ |
| 7 | End of Frame (EOF) | $T_{rv4}$ | 252 | 293 | 314 | $t_{bdlc}$ |
| 8 | Inter-Frame Separator (IFS) | $T_{rv5}$ | 315 | — | — | $t_{bdlc}$ |
| 9 | Break Signal (BREAK) | $T_{rv6}$ | 252 | — | — | $t_{bdlc}$ |

**Note:**

1. The receiver symbol timing boundaries are subject to an uncertainty of 1 $t_{bdlc}$ due to sampling considerations.

**Table 20-19. BDLC Receiver VPW 4X Symbol Timing for Integer Frequencies**

| Number | Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| 1 | Passive Logic 0 | $T_{rvp1}$ | 8 | 16 | 23 | $t_{bdlc}$ |
| 2 | Passive Logic 1 | $T_{rvp2}$ | 24 | 32 | 40 | $t_{bdlc}$ |
| 3 | Active Logic 0 | $T_{rva1}$ | 24 | 32 | 40 | $t_{bdlc}$ |
| 4 | Active Logic 1 | $T_{rva2}$ | 8 | 16 | 23 | $t_{bdlc}$ |
| 5 | Start of Frame (SOF) | $T_{rva3}$ | 41 | 50 | 59 | $t_{bdlc}$ |
| 6 | End of Data (EOD) | $T_{rvp3}$ | 41 | 50 | 59 | $t_{bdlc}$ |
| 7 | End of Frame (EOF) | $T_{rv4}$ | 60 | 70 | 74 | $t_{bdlc}$ |
| 8 | Inter-Frame Separator (IFS) | $T_{rv5}$ | 75 | — | — | $t_{bdlc}$ |
| 9 | Break Signal (BREAK) | $T_{rv6}$ | 60 | — | — | $t_{bdlc}$ |

**Note:**

1. The receiver symbol timing boundaries are subject to an uncertainty of 1 $t_{bdlc}$ due to sampling considerations.

**Table 20-20. BDLC Receiver VPW 4X Symbol Timing for Binary Frequencies**

| Number | Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| 1 | Passive Logic 0 | $T_{rvp1}$ | 9 | 17 | 25 | $t_{bdlc}$ |
| 2 | Passive Logic 1 | $T_{rvp2}$ | 26 | 34 | 42 | $t_{bdlc}$ |
| 3 | Active Logic 0 | $T_{rva1}$ | 26 | 34 | 42 | $t_{bdlc}$ |
| 4 | Active Logic 1 | $T_{rva2}$ | 9 | 17 | 25 | $t_{bdlc}$ |
| 5 | Start of Frame (SOF) | $T_{rva3}$ | 43 | 53 | 62 | $t_{bdlc}$ |
| 6 | End of Data (EOD) | $T_{rvp3}$ | 43 | 53 | 62 | $t_{bdlc}$ |
| 7 | End of Frame (EOF) | $T_{rv4}$ | 63 | 74 | 78 | $t_{bdlc}$ |
| 8 | Inter-Frame Separator (IFS) | $T_{rv5}$ | 79 | — | — | $t_{bdlc}$ |
| [9] | Break Signal (BREAK) | $T_{rv6}$ | 63 | — | — | $t_{bdlc}$ |

**Note:**

1. The receiver symbol timing boundaries are subject to an uncertainty of 1 $t_{bdlc}$ due to sampling considerations.

The min and max symbol limits shown in the following sections (Invalid Passive Bit - Valid BREAK Symbol) and figures (Figure 20-14 - Figure 20-17) refer to the values listed in Table 20-15 throughTable 20-20.

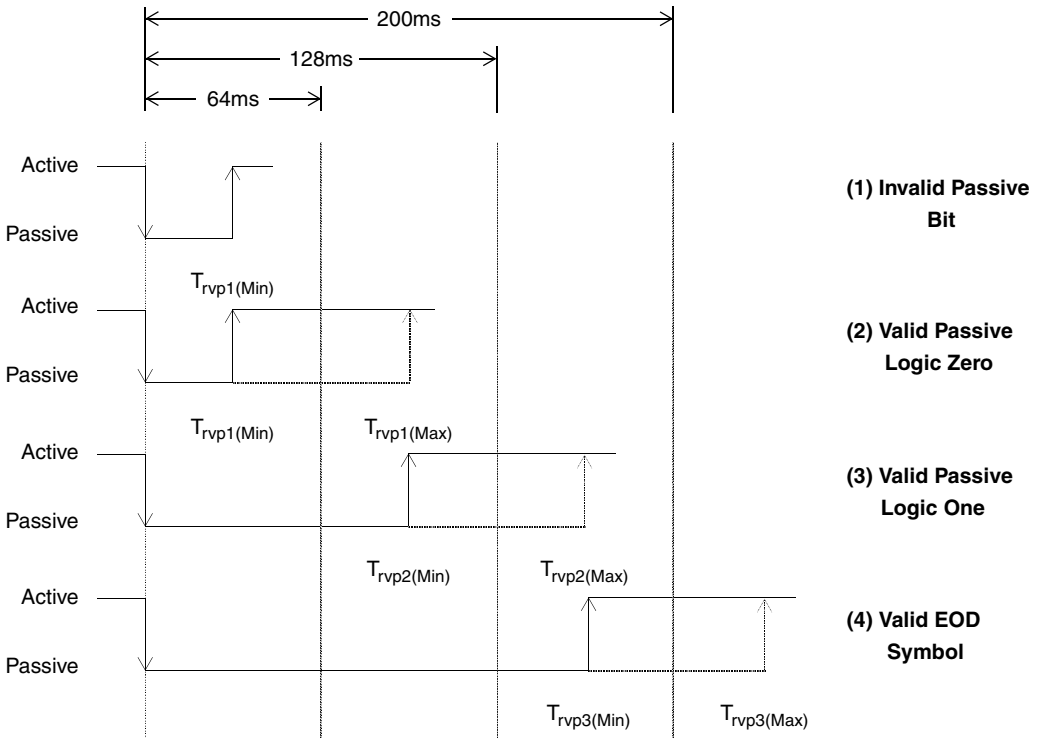



**Figure 20-14. J1850 VPW Passive Symbols**

- Invalid Passive Bit

  If the passive to active transition beginning the next data bit or symbol occurs between the active to passive transition beginning the current data bit or symbol and $T_{rvp1(Min)}$, the current bit would be invalid. See Figure 20-14(1).
- Valid Passive Logic Zero

  If the passive to active transition beginning the next data bit or symbol occurs between $T_{rvp1(Min)}$ and $T_{rvp1(Max)}$, the current bit would be considered a logic zero. See Figure 20-14(2).
- Valid Passive Logic One

  If the passive to active transition beginning the next data bit or symbol occurs between $T_{rvp2(Min)}$ and $T_{rvp2(Max)}$, the current bit would be considered a logic one. See Figure 20-14(3).
- Valid EOD Symbol

  If the passive to active transition beginning the next data bit or symbol occurs between $T_{rvp3(Min)}$ and $T_{rvp3(Max)}$, the current symbol would be considered a valid EOD symbol. See Figure 20-14(4).

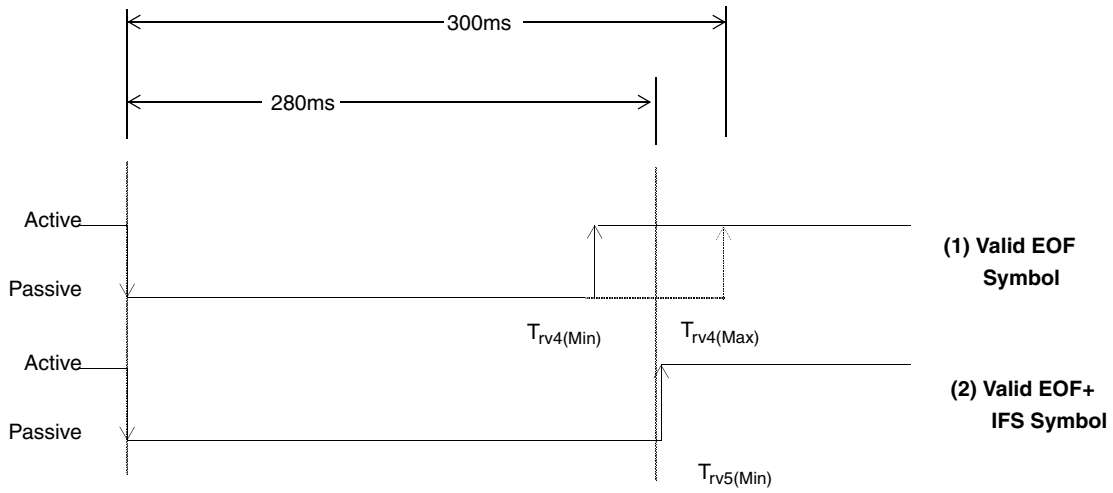



**Figure 20-15. J1850 VPW EOF and IFS Symbols**

- Valid EOF & IFS Symbol

  In Figure 20-15(1), if the passive to active transition beginning the SOF symbol of the next message occurs between $T_{rv4(Min)}$ and $T_{rv4(Max)}$, the current symbol will be considered a valid EOF symbol.

  If the passive to active transition beginning the SOF symbol of the next message occurs after $T_{rv5(Min)}$, the current symbol will be considered a valid EOF symbol followed by a valid IFS symbol. See Figure 20-15(2). All nodes must wait until a valid IFS symbol time has expired before beginning transmission. However, due to variations in clock frequencies and bus loading, some nodes may recognize a valid IFS symbol before others, and immediately begin transmitting. Therefore, anytime a node waiting to transmit detects a passive to active transition once a valid EOF has been detected, it should immediately begin transmission, initiating the arbitration process.

- Idle Bus

  If the passive to active transition beginning the SOF symbol of the next message does not occur before $T_{tv5(Min)}$, the bus is considered to be idle, and any node wishing to transmit a message may do so immediately.

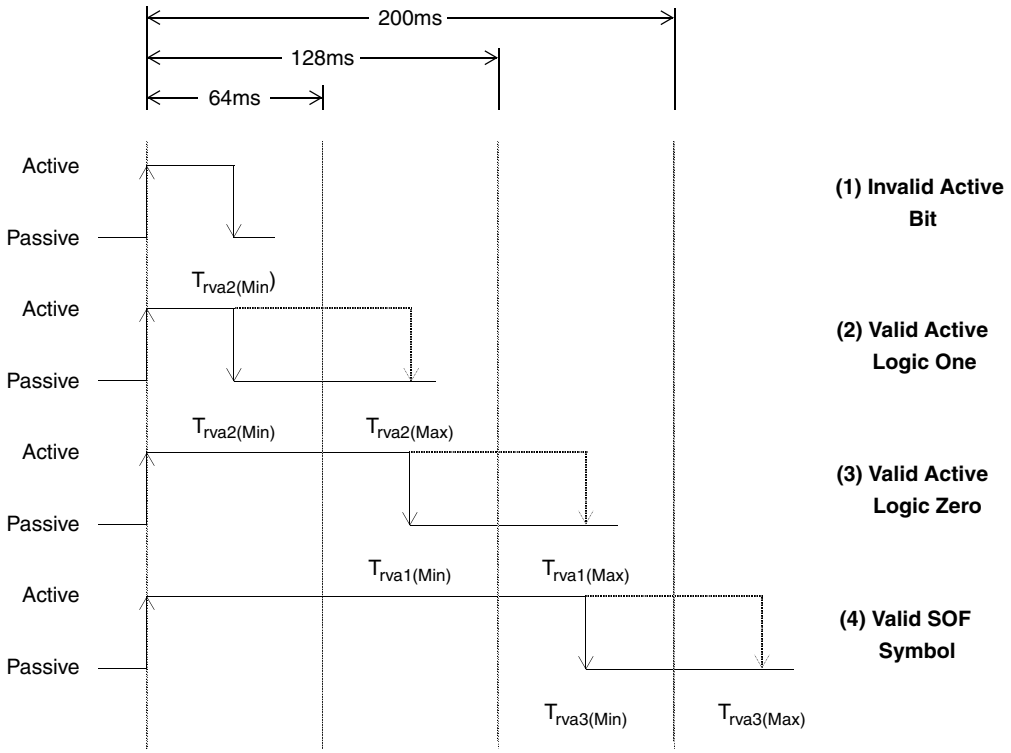



**Figure 20-16. J1850 VPW Active Symbols**

- Invalid Active Bit

  If the active to passive transition beginning the next data bit or symbol occurs between the passive to active transition beginning the current data bit or symbol and $T_{rva2(Min)}$, the current bit would be invalid. See Figure 20-16(1).
- Valid Active Logic One

  If the active to passive transition beginning the next data bit or symbol occurs between $T_{rva2(Min)}$ and $T_{rva2(Max)}$, the current bit would be considered a logic one. See Figure 20-16(2).
- Valid Active Logic Zero

  If the active to passive transition beginning the next data bit or symbol occurs between $T_{rva1(Min)}$ and $T_{rva1(Max)}$, the current bit would be considered a logic zero. See Figure 20-16(3).
- Valid SOF Symbol

  If the active to passive transition beginning the next data bit or symbol occurs between $T_{rva3(Min)}$ and $T_{rva3(Max)}$, the current symbol would be considered a valid SOF symbol. See Figure 20-16(4).

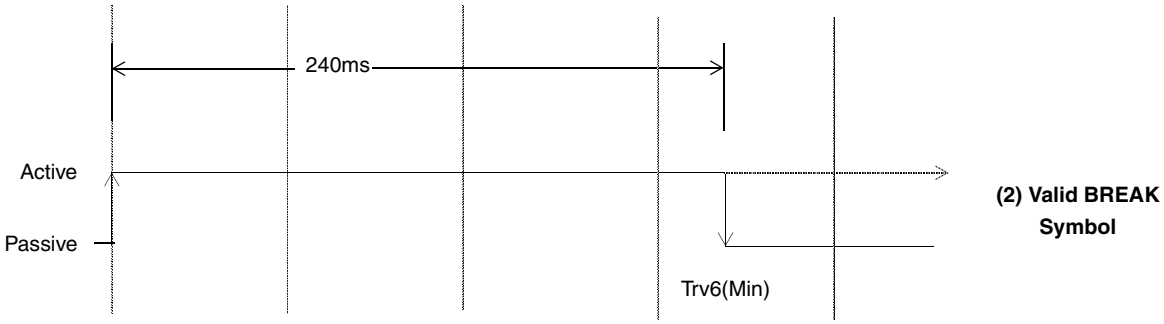



**Figure 20-17. J1850 VPW BREAK Symbol**

- Valid BREAK Symbol

  If the next active to passive transition does not occur until after $T_{rv6(Min)}$, the current symbol will be considered a valid BREAK symbol. A BREAK symbol should be followed by a SOF symbol beginning the next message to be transmitted onto the J1850 bus. See Figure 20-17.

- Message Arbitration

  Message arbitration on the J1850 bus is accomplished in a non-destructive manner, allowing the message with the highest priority to be transmitted, while any transmitters which lose arbitration simply stop transmitting and wait for an idle bus to begin transmitting again.

  If the BDLC module wishes to transmit onto the J1850 bus, but detects that another message is in progress, it automatically waits until the bus is idle. However, if multiple nodes begin to transmit in the same synchronization window, message arbitration will occur beginning with the first bit after the SOF symbol and continue with each bit thereafter.

  The VPW symbols and J1850 bus electrical characteristics are carefully chosen so that a logic zero (active or passive type) will always dominate over a logic one (active or passive type) simultaneously transmitted. Hence logic zeroes are said to be ‘dominant’ and logic ones are said to be ‘recessive’.

  Whenever a node transmits a recessive bit and detects a dominant bit, it loses arbitration, and immediately stops transmitting. This is known as bitwise arbitration.The loss of arbitration flag (in BDLC State Vector Register) is set when arbitration is lost. If the interrupt enable bit (IE in BDLC Control Register 1) is set, an interrupt request from the BDLC module is generated. Reading the BDLC State Vector Register register will clear this flag.

  During arbitration, or even throughout the transmitting message, when an opposite bit is detected, transmission is immediately stopped unless it occurs on the 8th bit of a byte. In this case the BDLC module will automatically append up to two extra 1 bits and then stop transmitting. These two extra bits will be arbitrated normally and thus will not interfere with another message. The second 1 bit will not be sent if the first loses arbitration. If the BDLC module has lost arbitration to another valid message then the two extra ones will not corrupt the current message. However, if the BDLC module has lost arbitration due to noise on the bus, then the two extra ones will ensure that the current message will be detected and ignored as a noise-corrupted message.

  Since a “0” dominates a “1”, the message with the lowest value will have the highest priority, and will always win arbitration, i.e. a message with priority 000 will win arbitration over a message with priority 011. This method of arbitration will work no matter how many bits of priority encoding are contained in the message.

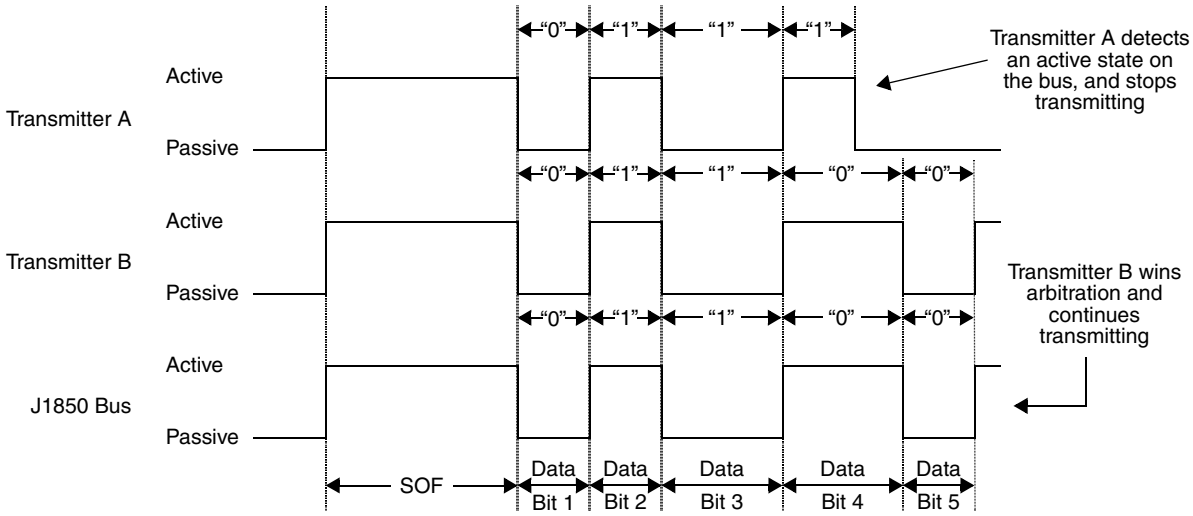



**Figure 20-18. J1850 VPW Bitwise Arbitrations**

### 20.8.1.4 J1850 Bus Errors

The BDLC module detects several types of transmit and receive errors which can occur during the transmission of a message onto the J1850 bus.

- Transmission Error

  If the BDLC module is transmitting a message and the message received contains a symbol error, a framing error, a bus fault, a BREAK symbol, or a logic '1' symbol when a logic "0" is being transmitted, this constitutes a transmission error. Receiving a logic '0' symbol when transmitting a logic '1' is considered a loss of arbitration condition (See Message Arbitration) and not a transmission error. When a transmission error is detected, the BDLC module will immediately cease transmitting. Further transmission or reception will be disabled until a valid EOF symbol is detected on the J1850 bus. The error condition is reflected by setting the symbol invalid or out of range flag in the BDLC State Vector Register register. If the interrupt enable bit (IE in BDLC Control Register 1) is set, an interrupt request from the BDLC module is generated. Reading the BDLC State Vector Register register will clear this flag.

- CRC Error

  A cyclical redundancy check (CRC) error is detected when the data bytes and CRC byte of a received message are processed, and the CRC calculation result is not equal to $C4.The CRC code should detect any single and 2 bit errors, as well as all 8 bit burst errors, and almost all other types of errors. The CRC error flag (in BDLC State Vector Register) is set when a CRC error is detected. If the interrupt enable bit (IE in BDLC Control Register 1) is set, an interrupt request from the BDLC module is generated. Reading the BDLC State Vector Register register will clear this flag.

- Symbol Error

  A symbol error is detected when an abnormal (invalid) symbol is detected in a message being received from the J1850 bus. See sections Invalid Passive Bit and Invalid Active Bit which define invalid symbols.The symbol invalid or out of range flag (in BDLC State Vector Register) is set when a symbol error is detected. If the interrupt enable bit (IE in BDLC Control Register 1) is set,

an interrupt request from the BDLC module is generated. Reading the BDLC State Vector Register register will clear this flag.

- Framing Error

  A framing error is detected when a received symbol occurs in an inappropriate location in the message frame. The following situations result in framing errors:

  — An active logic “0” or logic “1” received as the first symbol of the frame.
  — An SOF symbol received in any location other than the first symbol of a frame. Erroneous locations include: Within the data portion of a message or IFR; Immediately following the EOD in a message or IFR.
  — An EOD symbol received on a non-byte boundary in a message or IFR.
  — An active logic “0” or logic “1” received immediately following the EOD at the end of an IFR.

  The symbol invalid or out of range flag (in BDLC State Vector Register) is set when a framing error is detected. If the interrupt enable bit (IE in BDLC Control Register 1) is set, an interrupt request from the BDLC module is generated. Reading the BDLC State Vector Register register will clear this flag.

- Bus Fault

  If a bus fault occurs, the response of the BDLC module will depend upon the type of bus fault.

  If the bus is shorted to $V_{DD}$, the BDLC module will wait for the bus to fall to a passive state before it will attempt to transmit a message. As long as the short remains, the BDLC will never attempt to transmit a message onto the J1850 bus.

  If the bus is shorted to ground, the BDLC module will see an idle bus, begin to transmit the message, and then detect a transmission error, since the short to ground would not allow the bus to be driven to the active (dominant) state. The BDLC module will wait for assertion of the receive pin for (64 - analog round trip delay) $t_{bdlc}$ cycles, after assertion of the transmit pin, before detecting the error. If the transmission is an IFR, the BDLC module will wait for (280 - analog round trip delay) $t_{bdlc}$ cycles before detecting an error. The “analog round trip delay” is determined by the value stored in the BDLC Analog Round Trip Delay Register register. The BDLC module will set the symbol invalid or out of range flag (in BDLC State Vector Register), abort that transmission and wait for the next CPU command to transmit. In this case, the transmitter does not have to wait for an EOF symbol to be received to be enabled. If the interrupt enable bit (IE in BDLC Control Register 1) is set, an interrupt request from the BDLC module is generated. Reading the BDLC State Vector Register register will clear this flag.

  In any case, if the bus fault is temporary, as soon as the fault is cleared, the BDLC module will resume normal operation. If the bus fault is permanent, it may result in permanent loss of communication on the J1850 bus.

- BREAK — Break

  Any BDLC transmitting at the time a BREAK is detected will treat the BREAK as if a transmission error had occurred, and halt transmission.

  If while receiving a message the BDLC module detects a BREAK symbol, it will treat the BREAK as a reception error.

If a BREAK symbol is received while the BDLC module is transmitting or receiving, the symbol invalid or out of range flag (in BDLC State Vector Register) is set. Further transmission/reception will be disabled until the J1850 bus returns to the passive state and a valid EOF symbol is detected on the J1850 bus. If the interrupt enable bit (IE in BDLC Control Register 1) is set, an interrupt request from the BDLC module is generated. Reading the BDLC State Vector Register register will clear this flag.

The BDLC module can transmit a BREAK symbol. And it can receive a BREAK symbol from the J1850 bus.

- Bus Error Summary

  The possible J1850 bus errors and the actions taken by the BDLC module are summarized in Table 20-21.

**Table 20-21. BDLC Module J1850 Error Summary**

| Error Condition | BDLC Module Function |
|---|---|
| Transmission Error | BDLC module will immediately cease transmitting. Further transmission and reception will be disabled until a valid EOF symbol is detected. The symbol invalid or out of range flag will be set and interrupt generated if enabled. |
| Cyclical Redundancy Check (CRC) Error | CRC error flag set and interrupt generated if enabled. |
| Symbol Error | The symbol invalid or out of range flag will be set and interrupt generated if enabled. Transmission and reception will be disabled until a valid EOF symbol is detected. |
| Framing Error | The symbol invalid or out of range flag will be set and interrupt generated if enabled. Transmission and reception will be disabled until a valid EOF symbol is detected. |
| Bus short to $V_{DD}$. | The BDLC module will not transmit until short is corrected and a valid EOF is detected. Depending upon when short occurs and is corrected, this error condition may set the symbol invalid or out of range, crc error, or loss of arbitration flags. |
| Bus short to GND. | Short will be seen as an idle bus by BDLC module. If a transmission attempt is made before short is corrected, the symbol invalid or out of range flag will be set and interrupt generated if enabled. Another transmission can be initiated as soon as short is corrected. |
| BREAK symbol reception | If doing so, the BDLC module will immediately cease transmitting. Symbol invalid or out of range flag set and interrupt generated if enabled.Transmission and reception will be disabled until a valid EOF symbol is detected. |

## 20.8.2 Mux Interface

The MUX Interface is responsible for bit encoding/decoding and digital noise filtering between the Protocol Handler and the Physical Interface. Refer to Figure 20-2.

### 20.8.2.1 Mux Interface — Rx Digital Filter

The Receiver section of the BDLC module includes a digital low pass filter to remove narrow noise pulses from the incoming message. An outline of the digital filter is shown in Figure 20-19.

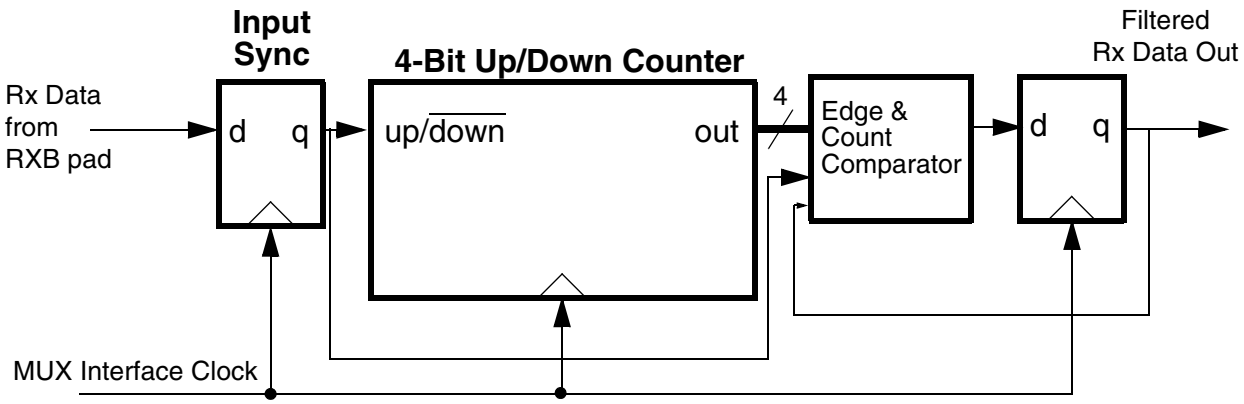



**Figure 20-19. BDLC Module Rx Digital Filter Block Diagram**

- Operation

  The clock for the digital filter is provided by the MUX Interface clock.At each positive edge of the clock signal, the current state of the Receiver input signal from the RXB pad is sampled.The RXB signal state is used to determine whether the counter should increment or decrement at the next positive edge of the clock signal.

  The counter will increment if the input data sample is high but decrement if the input sample is low.The counter will thus progress up towards ‘15’ if, on average, the RXB signal remains high or progress down towards ‘0’ if, on average, the RXB signal remains low.

  When the counter eventually reaches the value ‘15’, the digital filter decides that the condition of the RXB signal is at a stable logic level one and the Data Latch is set, causing the Filtered Rx Data signal to become a logic level one. Furthermore, the counter is prevented from overflowing and can only be decremented from this state.

  Alternatively, should the counter eventually reach the value ‘0’, the digital filter decides that the condition of the RXB signal is at a stable logic level zero and the Data Latch is reset, causing the Filtered Rx Data signal to become a logic level zero. Furthermore, the counter is prevented from underflowing and can only be incremented from this state.

  The Data Latch will retain its value until the counter next reaches the opposite end point, signifying a definite transition of the RXB signal.

- Performance

  The performance of the digital filter is best described in the time domain rather than the frequency domain.

  If the signal on the RXB signal transitions, then there will be a delay before that transition appears at the Filtered Rx Data output signal. This delay will be between 15 and 16 clock periods, depending on where the transition occurs with respect to the sampling points. This ‘filter delay’ must be taken into account when performing message arbitration.

  For example, if the frequency of the MUX Interface clock ($f_{bdlc}$) is 1.0486MHz, then the period ($t_{bdlc}$) is 954ns and the maximum filter delay in the absence of noise will be 15.259us.

  The effect of random noise on the RXB signal depends on the characteristics of the noise itself. Narrow noise pulses on the RXB signal will be completely ignored if they are shorter than the filter delay. This provides a degree of low pass filtering.

If noise occurs during a symbol transition, the detection of that transition may be delayed by an amount equal to the length of the noise burst. This is just a reflection of the uncertainty of where the transition is truly occurring within the noise.

Noise pulses that are wider than the filter delay, but narrower than the shortest allowable symbol length will be detected by the next stage of the BDLC module's receiver as an invalid symbol.

Noise pulses that are longer than the shortest allowable symbol length will normally be detected as an invalid symbol or as invalid data when the frame's CRC is checked.

## 20.8.3 Protocol Handler

The Protocol Handler is responsible for framing, collision detection, arbitration, CRC generation/checking, and error detection. The Protocol Handler conforms to SAE J1850 - Class B Data Communications Network Interface. Refer to Figure 20-2

### 20.8.3.1 Protocol Architecture

The Protocol Handler contains the State Machine, Rx Shadow Register, Tx Shadow Register, Rx Shift Register, Tx Shift Register, and Loopback Multiplexer as shown in Figure 20-20. Each block will now be described in more detail.

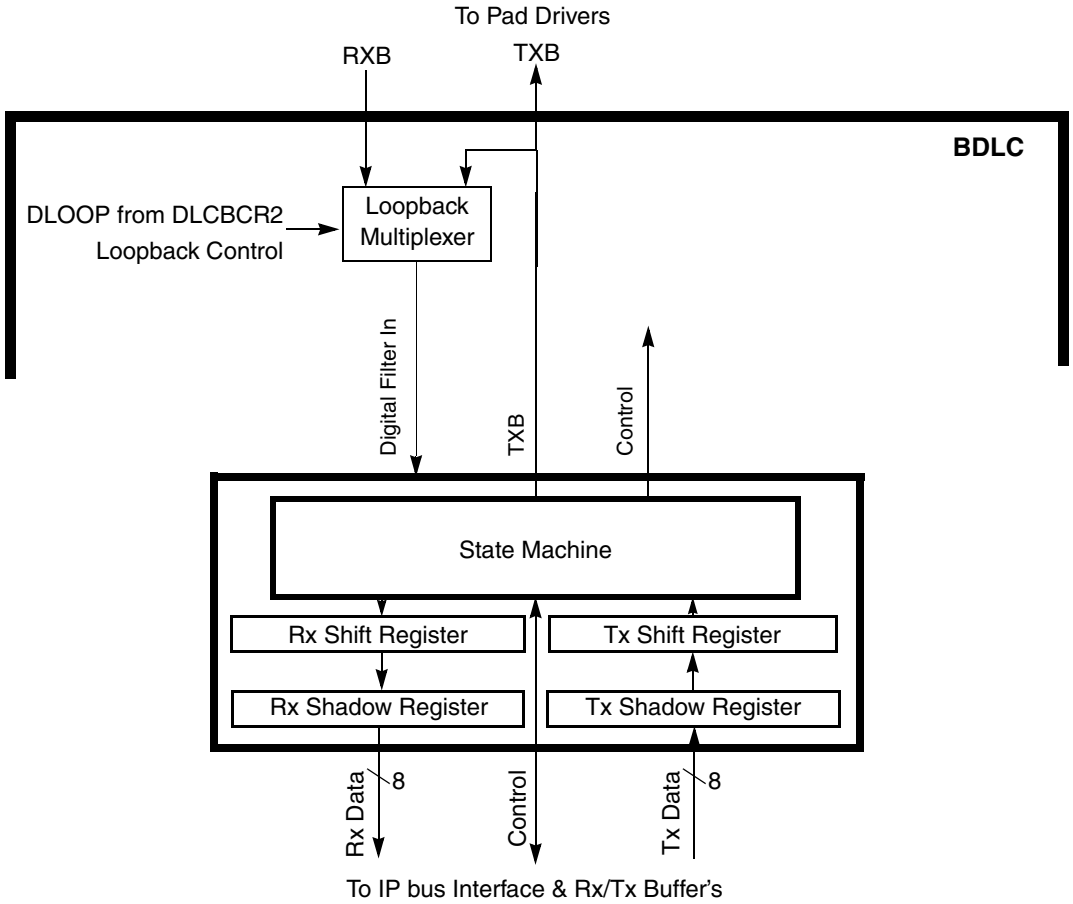



**Figure 20-20. BDLC Protocol Handler Outline**

- Rx & Tx Shift Registers

  The Rx Shift Register gathers received serial data bits from the J1850 bus and makes them available in parallel form to the Rx Shadow Register. The Tx Shift Register takes data, in parallel form, from the Tx Shadow Register and presents it serially to the State Machine so that it can be transmitted onto the J1850 bus.

- Rx & Tx Shadow Registers

  Immediately after the Rx Shift Register has completed shifting in a byte of data, this data is transferred to the Rx Shadow Register and RDRF or RXIFR is set and interrupt is generated if the interrupt enable bit (IE) in BDLC Control Register 1 is set. After the transfer takes place, this new data byte in the Rx Shadow Register is available to the CPU, and the Rx Shift Register is ready to shift in the next byte of data. Data in Rx Shadow Register must be retrieved by the CPU before it is overwritten by new data from the Rx Shift Register.

  Once the Tx Shift Register has completed its shifting operation for the current byte, the data byte in the Tx Shadow Register is loaded into the Tx Shift Register. After this transfer takes place, the Tx Shadow Register is ready to accept new data from the CPU.

- Digital Loopback Multiplexer

  The Digital Loopback Multiplexer connects the input of the receive digital filter (See Figure 20-20) to either the transmit signal out to the pad (TXB) or the receive signal from the pad (RXB), depending on the state of the DLOOP bit in BDLC Control Register 2 register.

- State Machine

  All of the functions associated with performing the protocol are executed or controlled by the State Machine. The State Machine is responsible for framing, collision detection, arbitration, CRC generation/checking, and error detection. The following sections describe the BDLC module's actions in a variety of situations.

- 4X Mode

  The BDLC module can exist on the same J1850 bus as modules which use a special 4X (41.6 kbps) mode of J1850 VPW operation. The BDLC module can transmit and receive messages in 4X mode, if the 4XE bit is set in BDLC Control Register 2. If the 4XE bit is not set in the BDLC Control Register 2, any 4X message on the J1850 bus is treated as noise by the BDLC module and is ignored. Likewise, 4X messages transmitted on the SAE J1850 bus when the BDLC module is in normal mode will be interpreted as noise on the network by the BDLC module.

- Receiving a Message in Block Mode

  Although not a part of the SAE J1850 protocol, the BDLC module does allow for a special "Block Mode" of operation of the receiver. As far as the BDLC module is concerned, a Block Mode message is simply a long J1850 frame that contains an indefinite number of data bytes. All of the other features of the frame remain the same, including the SOF, CRC, and EOD symbols.

  Another node wishing to send a Block Mode transmission must first inform all other nodes on the network that this is about to happen. This is usually accomplished by sending a special predefined message.

- Transmitting a Message in Block Mode

  A Block mode message is transmitted inherently by simply loading the bytes one by one into the BDLC Data Register register until the message is complete. The programmer should wait until the TDRE flag is set prior to writing a new byte of data into the BDLC Data Register register. The BDLC module does not contain any predefined maximum J1850 message length requirement.

## 20.8.4 Transmitting A Message

The design of the BDLC module enables the user to easily handle message reception and message transmission separately. This can greatly simplify the communication software, as all received messages can be handled virtually the same, regardless of their origin.

This chapter will therefore describe only the steps necessary for transmitting a message, and will not address the resulting reception of that message by the BDLC module. Message reception is described in Section 20.8.5, “Receiving A Message”. Later sections will deal with transmitting and receiving In-Frame Responses on the SAE J1850 bus.

### 20.8.4.1 BDLC Transmission Control Bits

There is only one BDLC module control bit which is used when transmitting a message onto the SAE J1850 bus. This bit, the Transmit End of Data (TEOD) bit, is set by the user to indicate to the BDLC module that the last byte of that part of the message frame has been loaded into the BDLC Data Register. The TEOD bit, located in BDLC Control Register 2, is also used when transmitting an In-Frame Response (IFR), but that usage is described in Section 20.8.6, “Transmitting An In-Frame Response (IFR)”. Setting the TEOD bit indicates to the BDLC module that the last byte written to the BDLC Data Register is the final byte to be transmitted, and that following this byte a CRC byte and EOD symbol should be transmitted automatically. Setting the TEOD bit will also inhibit any further TDRE interrupts until TEOD is cleared. The TEOD bit will be cleared on the rising edge of the first bit of the transmitted CRC byte, or if an error or loss of arbitration is detected on the bus.

- BDLC Data Register

  The BDLC Data Register is a double-buffered register which is used for handling the transmitted and received message bytes.Bytes to be transmitted onto the SAE J1850 bus are written to the BDLC Data Register, and bytes received from the bus by the BDLC module are read from the BDLC Data Register. Since this register is double buffered, bytes written into it cannot be read by the CPU. If this is attempted, the byte which is read will be the last byte placed in the BDLC Data Register by the BDLC module, not the last byte written to the BDLC Data Register by the CPU. For an illustration of the BDLC Data Register, refer to Section 20.7.3.4, “BDLC Data Register (DLCBDR)”.

- Transmitting a Message with the BDLC

  To transmit a message using the BDLC module, the user just writes the first byte of the message to be transmitted into the BDLC Data Register, initiating the transmission process. When the TDRE status appears in the BDLC State Vector Register, the user writes the next byte into the BDLC Data Register. Once all of the bytes have been loaded into the BDLC Data Register, the user sets the TEOD bit, and the BDLC module completes the message transmission. What follows is an

overview of the basic steps required to transmit a message onto an SAE J1850 network using the BDLC module. For an illustration of this sequence, refer to Figure 20-21.

**NOTE**

Due to the byte-level architecture of the BDLC module, the 12-byte limit on message length as defined in SAE J1850 must be enforced by the user's software. The number of bytes in a message (transmitted or received) has no meaning to the BDLC module.

– Step 1: Write the First Byte into the BDLC Data Register

To initiate a message transmission, the CPU simply loads the first byte of the message to be transmitted into the BDLC Data Register. The BDLC module will then perform the necessary bus acquisition duties to determine when the message transmission can begin.

Once the BDLC module determines that the SAE J1850 bus is free, a Start of Frame (SOF) symbol will be transmitted, followed by the byte written to the BDLC Data Register. Once the BDLC module readies this byte for transmission, the BDLC State Vector Register will reflect that the next byte can be written to the BDLC Data Register (TDRE interrupt).

**NOTE**

If the user writes the first byte of a message to be transmitted to the BDLC Data Register and then determines that a different message should be transmitted, the user can write a new byte to the BDLC Data Register up until the transmission begins. This new byte will replace the original byte in the BDLC Data Register.

— Step 2: When TDRE is Indicated, Write the Next Byte into the BDLC Data Register

When a TDRE state is reflected in the BDLC State Vector Register, the CPU writes the next byte to be transmitted into the BDLC Data Register. This step is repeated until the last byte to be transmitted is written to the BDLC Data Register.

**NOTE**

Due to the design and operation of the BDLC module, when transmitting a message the user may write two, or possibly even three of the bytes to be transmitted into the BDLC Data Register before the first RDRF interrupt occurs. For this reason, the user should never use receive interrupts to control the sequencing of bytes to be transmitted.

— Step 3: Write the Last Byte to the BDLC Data Register and Set TEOD

Once the user has written the last byte to be transmitted into the BDLC Data Register, the user then sets the TEOD bit in BDLC Control Register 2. When the TEOD bit is set, once the byte written to the BDLC Data Register is transmitted onto the bus, the BDLC module will begin transmitting the 8-bit CRC byte, as specified in SAE J1850. Following the CRC byte, the BDLC module will transmit an EOD symbol onto the SAE J1850 bus, indicating that this part of the message has been completed. If no IFR bytes are transmitted following the EOD, an EOF will be recognized and the message will be complete.

Setting the TEOD bit is the last step the CPU needs to take to complete the message transmission, and no further transmission-related interrupts will occur. Once the message has been completely received by the BDLC module, an EOF interrupt will be generated. However, this is technically a receive function which can be handled by the message reception routine.

**NOTE**

While the TEOD bit is typically set immediately following the write of the last byte to the BDLC Data Register, it is also acceptable to wait until a TDRE interrupt is generated before setting the TEOD bit. While the example flowchart in Figure 20-21 shows the TEOD bit being set after the write to the BDLC Data Register, either method is correct. If a TDRE interrupt is pending, it will be cleared when the TEOD bit is set.

### 20.8.4.2 Transmitting Exceptions

While this is the basic transmit flow, at times the message transmit process will be interrupted. This can be due to a loss of arbitration to a higher priority message or due to an error being detected on the network. For the transmit routine, either of these events can be dealt with in a similar manner.

- Loss of Arbitration

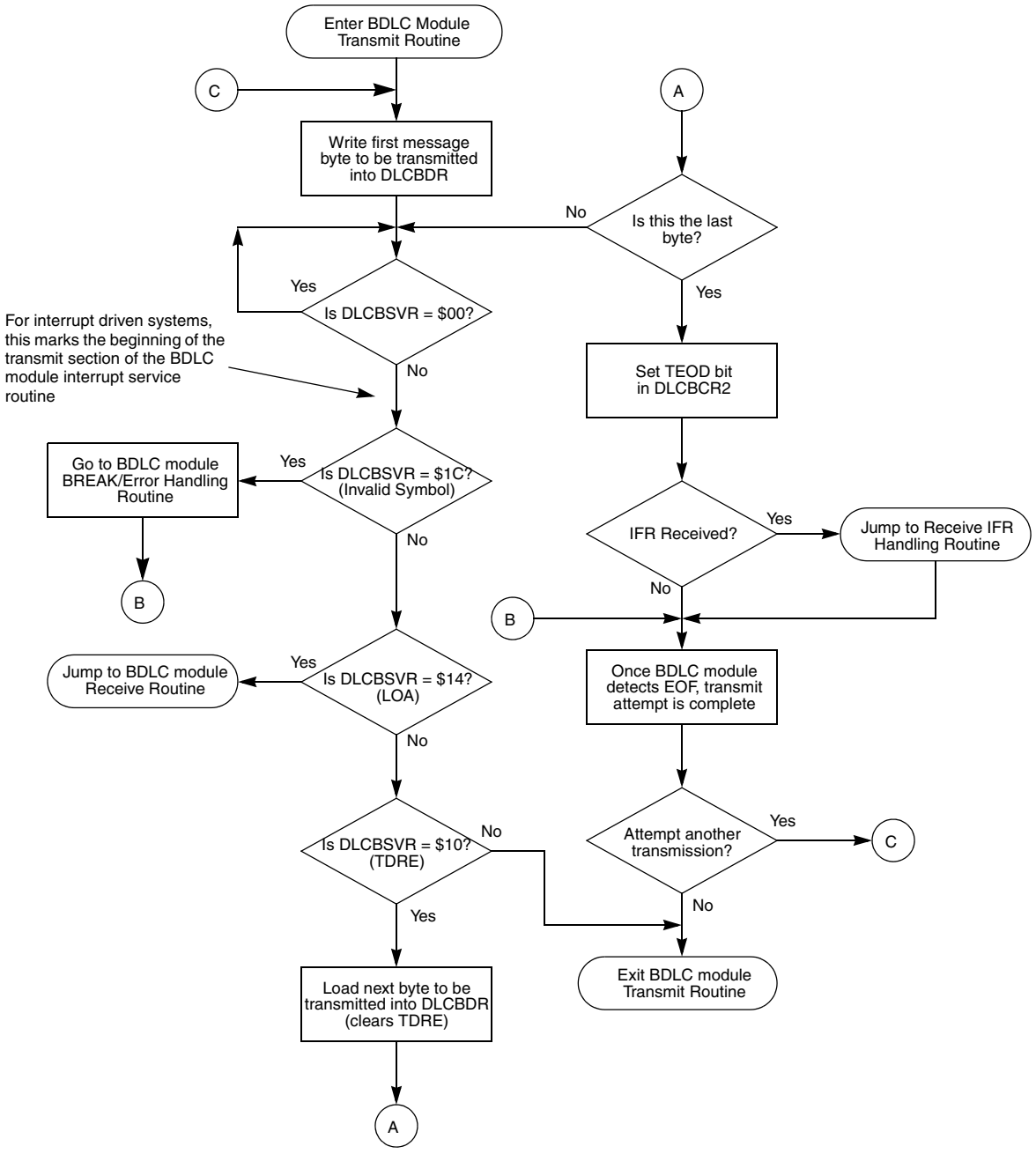
  If a loss of arbitration (LOA) occurs while the BDLC module is transmitting onto the SAE J1850 bus, the BDLC module will immediately stop transmitting, and a LOA status will be reflected in the BDLC State Vector Register. If the loss of arbitration has occurred on a byte boundary, an RDRF interrupt may also be pending once the LOA interrupt is cleared.

  When a loss of arbitration occurs, the J1850 message handling software should immediately switch into the receive mode. If the TEOD bit was set, it will be cleared automatically. **If another attempt is to be made to transmit the same message, the user must start the transmit sequence over from the beginning of the message.**

- Error Detection

  Similar to a loss of arbitration, if any error (except a CRC error) is detected on the SAE J1850 bus during a transmission, the BDLC module will stop transmitting immediately. The byte which was being transmitted will be discarded, and the “Symbol Invalid or Out of Range” status will be reflected in the BDLC State Vector Register. As with the loss of arbitration, if the TEOD bit was set, it will be cleared automatically, and any attempt to transmit the same message will have to start from the beginning.

  If a CRC error occurs following a transmission, this will also be reflected in the BDLC State Vector Register. However, since the CRC error is really a receive error based on the received CRC byte, at this point all bytes of the message will have been transmitted. It is therefore up to the user’s software to determine if another attempt should be made to transmit the message in which the error occurred.




NOTE: The EOF and CRC Error interrupts are handled in the BDLC module Receive Routine

**Figure 20-21. Basic BDLC Transmit Flowchart**

- Transmitter Underrun

  A transmitter underrun can occur when a TDRE interrupt is not serviced in a timely fashion. If the last byte loaded into the BDLC Data Register is completely transmitted onto the network before the next byte is loaded into the BDLC Data Register, a transmitter underrun will occur. If this does happen, the BDLC module will transmit two additional logic ones to ensure that the partial message which was transmitted onto the bus does not end on a byte boundary. This will be followed by an EOD and EOF symbol. The only indication to the CPU that an underrun occurred is the

Symbol Invalid or Out of Range error which will be indicated in the BDLC State Vector Register. As with the other errors, it is up to the user's software to determine if another transmission attempt should be made.

- In-Frame Response to a Transmitted Message

  If an In-Frame Response (IFR) is received following the transmission of a message, the status indicating that an IFR byte has been received will be indicated in the BDLC State Vector Register before an EOF is indicated. Refer to Section 20.8.7, "Receiving An In-Frame Response (IFR)" for a description of how to handle the reception of IFR bytes.

#### 20.8.4.3 Aborting a Transmission

The BDLC module does not have a mechanism designed specifically for aborting a transmission. Since the module transmits each message on a byte-by-byte basis, there is little need to implement an abort mechanism. If the user has loaded a byte into the BDLC Data Register to initiate a message transmission and decides to send a different message, the byte in the BDLC Data Register can be replaced, right up to the point that the message transmission begins.

If the user has loaded a byte into the BDLC Data Register and then decides not to send any message at all, the user can let the byte transmit, and when the TDRE interrupt occurs let the transmitter underrun. This will cause two extra logic ones followed by an EOF to be transmitted. While this method may require a small amount of bus bandwidth, the need to do this should be very rare. Replacing the byte originally written to the BDLC Data Register with $FF will also increase the probability of the transmitter losing arbitration if another node begins transmitting at the same time, also reducing the bus bandwidth needed.

### 20.8.5 Receiving A Message

The design of the BDLC module makes it especially easy to use for receiving messages off of the SAE J1850 bus. When the first byte of a message comes in, the BDLC State Vector Register will indicate to the CPU that a byte has been received. As each successive byte is received, that will in turn be reflected in the BDLC State Vector Register. When the message is complete and the EOF has been detected on the bus, the BDLC State Vector Register will reflect this, indicating that the message is complete.

The basic steps required for receiving a message from the SAE J1850 bus are outlined below. For more information on receiving IFR bytes, refer to Section 20.8.7, "Receiving An In-Frame Response (IFR)".

#### 20.8.5.1 BDLC Reception Control Bits

The only control bit which is used for message reception, the IMSG bit, is actually used to prevent message reception. When the IMSG bit is set BDLC module interrupts of the CPU are inhibited until the next SOF symbol is received. This allows the BDLC module to ignore the remainder of a message once the CPU has determined that it is of no interest. This helps reduce the amount of CPU overhead used to service messages received from the SAE J1850 network, since otherwise the BDLC module would require attention from the CPU for each byte broadcast on the network. The IMSG bit is cleared when the BDLC module receives an SOF symbol, or it can also be cleared by the CPU.

**NOTE**

While the IMSG bit can be used to prevent the CPU from having to service the BDLC module for every byte transmitted on the SAE J1850 bus, **the IMSG bit should never be used to ignore the BDLC module's own transmission**. Because setting the IMSG bit prevents all BDLC State Vector Register bits from being updated until an SOF is received, the user would not receive any further transmit-related interrupts until another SOF was received, making it very difficult for the CPU to complete the transmission correctly.

### 20.8.5.2 Receiving a Message with the BDLC Module

Receiving a message using the BDLC module is extremely straight-forward. As each byte of a message is received and placed into the BDLC Data Register, the BDLC module will indicate this to the CPU with an Rx Data Register Full (RDRF) status in the BDLC State Vector Register. When an EOF symbol is received, indicating to the CPU that the message is complete, this too will be reflected in the BDLC State Vector Register.

Outlined below are the basic steps to be followed for receiving a message from the SAE J1850 bus with the BDLC module. For an illustration of this sequence, refer to Figure 20-22.

- Step 1: When RDRF Interrupt Occurs, Retrieve Data Byte

  When the first byte of a message following a valid SOF symbol is received that byte is placed in the BDLC Data Register, and an RDRF state is reflected in the BDLC State Vector Register. No indication of the SOF reception is made, since the end of the previous message is marked by an EOF indication. The first RDRF state following this EOF indication should allow the user to determine when a new message begins.

  The RDRF interrupt is cleared when the received byte is read from the BDLC Data Register. Once this is done, no further CPU intervention is necessary until the next byte is received, and this step is repeated.

  All bytes of the message, including the CRC byte, will be placed into the BDLC Data Register as they are received for the CPU to retrieve.

- Step 2: When an EOF is Received, the Message is Complete

  Once all bytes (including the CRC byte) have been received from the bus, the bus will be idle for a time period equal to an EOD symbol. Once the EOD symbol is received, the BDLC module will verify that the CRC byte is correct. If the CRC byte is not correct, this will be reflected in the BDLC State Vector Register.

  If no In-Frame Response bytes are transmitted following the EOD symbol, the EOD will transition into an EOF symbol. When the EOF is received it will be reflected in the BDLC State Vector Register, indicating to the user that the message is complete. If IFR bytes do follow the first EOD symbol, once they are complete another EOD will be transmitted, followed by an EOF.

  Once the EOF state is reflected in the BDLC State Vector Register, this indicates to the user that the message is complete, and that when another byte is received it is the first byte of a new message.

### 20.8.5.3 Filtering Received Messages

No message filtering hardware is included on the BDLC module, so all message filtering functions must be performed in software. Because the BDLC module handles each message on a byte-by-byte basis, message filtering can be done as each byte is received, rather than after the entire message is complete. This enables the CPU to decide while a message is still in progress whether or not that message is of any interest.

At any point during a message, if the CPU determines that the message is of no interest the IMSG bit can be set. Setting the IMSG bit commands the BDLC module not to update the BDLC State Vector Register until the next valid SOF is received. This prevents the CPU from having to service the BDLC module for each byte of every message sent over the network.

### 20.8.5.4 Receiving Exceptions

As with a message transmission, this basic message reception flow can be interrupted if errors are detected by the BDLC module. This can occur if an incorrect CRC is detected or if an invalid or out of range symbol appears on the SAE J1850 bus. A problem can also arise if the CPU fails to service the BDLC Data Register in a timely manner during a message reception.

- Receiver Overrun

  Once a message byte has been received, the CPU must service the BDLC Data Register before the next byte is received, or the first byte will be lost. If the BDLC Data Register is not serviced quickly enough, the next byte received will be written over the previous byte in the BDLC Data Register. No receiver overrun indication is made to the CPU. If the CPU fails to service the BDLC module during the reception of an entire message, the byte remaining in the BDLC Data Register will be last byte received (usually a CRC byte).

  Once a receiver overrun occurs, there is no way for the CPU to recover the lost byte(s), so the entire message should be discarded. To prevent receiver overrun, the user should ensure that a BDLC RDRF interrupt will be serviced before the next byte can be received. When polling the BDLC State Vector Register, the user should select a polling interval which will provide timely monitoring of the BDLC module.

- CRC Error

  If a CRC error is detected during a message reception, this will be reflected in the BDLC State Vector Register once an EOD time is recognized by the BDLC module. Since all bytes of the message will have been received when this error is detected, it is up to the user to ensure that all the received message bytes are discarded.

- Invalid or Out of Range Symbol

  If an invalid or out of range symbol, a framing error or a BREAK symbol is detected on the SAE J1850 bus during the reception of a message, the BDLC module will immediately stop receiving the message and discard any partially received byte. The “Symbol Invalid or Out of Range” status will immediately be reflected in the BDLC State Vector Register. Following this the BDLC module will wait until the bus has been idle for a time period equal to an EOF symbol before receiving another message. As with the CRC error, the user should discard any partially received message if this occurs.

- In-Frame Response to a Received Message

  As mentioned above, if one or more IFR bytes are received following the reception of a message, the status indicating the reception of the IFR byte(s) will be indicated in the BDLC State Vector Register before the EOF is indicated. Refer to Section 20.8.7, “Receiving An In-Frame Response (IFR)” for a description of how to deal with the reception of IFR bytes.

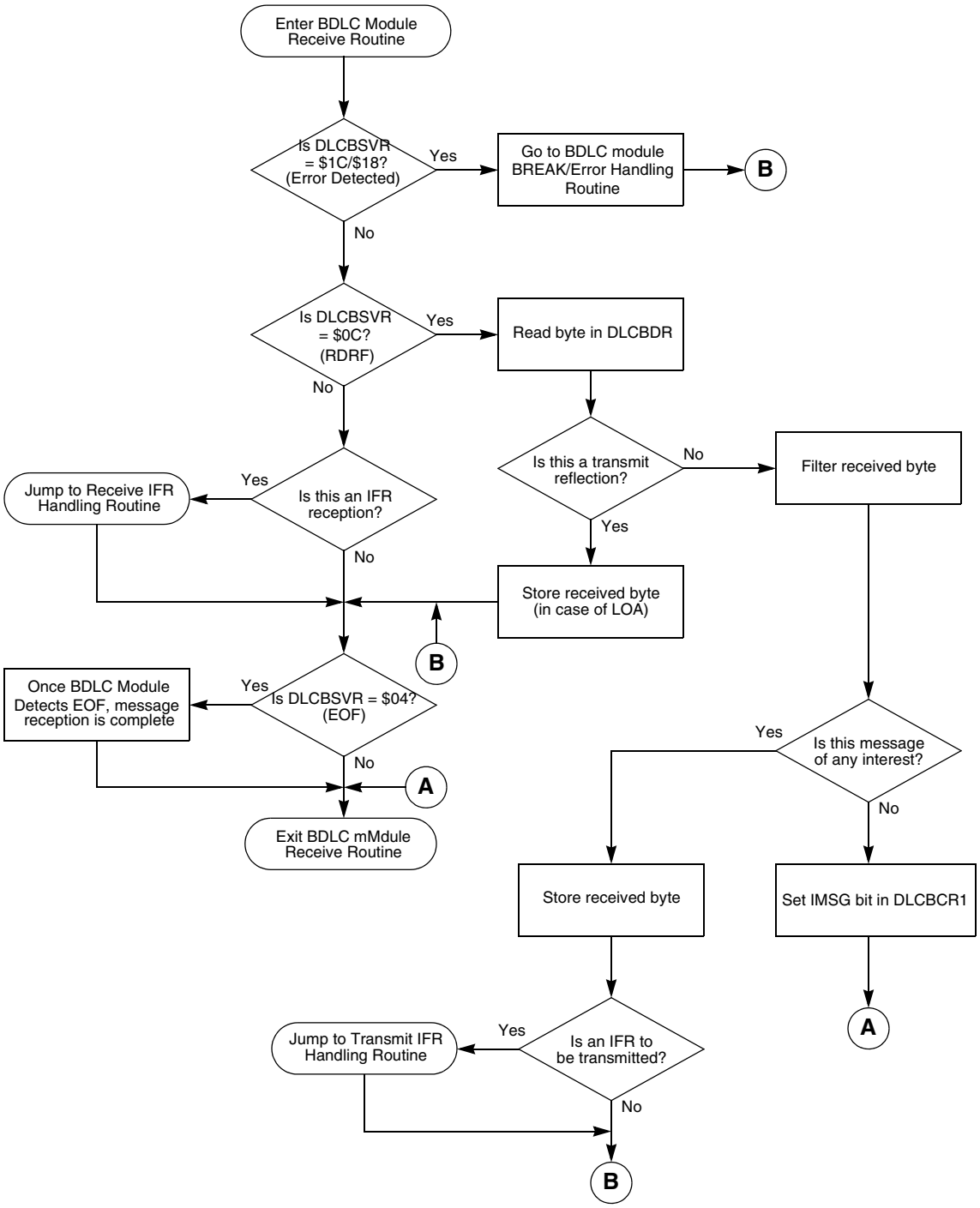



**Figure 20-22. Basic BDLC Receive Flowchart**

## 20.8.6 Transmitting An In-Frame Response (IFR)

The BDLC module can be used to transmit all four types of In-Frame Response (IFR) which are defined in SAE J1850. A very brief definition of each IFR type is given below. For a more detailed description of each, refer the SAE J1850 document.

The explanation regarding IFR support by the BDLC module which assumes the user is familiar with the use of IFRs as defined in SAE J1850, and understands the message header bit encoding and normalization bit formats which are used with the different types of IFRs. For more information on this, refer to the SAE J1850 document.

### 20.8.6.1 IFR Types Supported by the BDLC module

SAE J1850 defines four distinct types of IFR. The first (and most basic) IFR is Type 0, or no IFR. IFR types 1, 2 & 3 are each made up of one or more bytes and, depending upon the type used, may be followed by a CRC byte. The BDLC module is designed to allow the user to transmit and receive all types of SAE J1850 IFRs, but only the network framing/error checking/bus acquisition duties are performed by the BDLC module. The user is responsible for determining the type of IFR to be transmitted, the number of retries to be made (if allowed), and the allowable number of bytes to be transmitted.

- IFR Type 0: No Response

  The most basic type of IFR is no IFR. The Type 0 IFR, as defined in SAE J1850, is no response. The EOD and EOF symbols follow directly after the CRC byte at the end of the message frame being transmitted. This type of IFR is, of course, inherently supported by the BDLC module with no additional user intervention required.

- IFR Type 1: Single Byte from a Single Responder

  SAE J1850 defines the Type 1 IFR as a single byte from a single receiver. This type of IFR is used to acknowledge to the transmitter that the message frame was transmitted successfully on the network, and that at least one receiver received it correctly. A Type 1 IFR generally consists of the physical node ID of the receiver responding to the message, with no CRC byte appended. This type of response is used for Broadcast-type messages, where there may be several intended receivers for a message but the transmitter only wants to know that at least one node received it. In this case, all receivers will begin transmitting their node ID following the EOD. Since all nodes on an SAE J1850 network have a unique node ID, if multiple nodes begin transmitting their node ID simultaneously, arbitration takes place. The node with the highest priority (lowest value) ID wins this arbitration process, and that node's ID makes up the IFR. No retries are attempted by the nodes which lose arbitration during a Type 1 IFR transmission.

  A Type 1 IFR can also be used as a response to a physically addressed message, where the only intended receiver is the one which responds. In this case, no arbitration would take place during the IFR transmission, but the resulting IFR would still consist of a single byte.

- IFR Type 2: Single Byte from Multiple Responders

  The Type 2 IFR, as defined in SAE J1850, is a series of single bytes, each transmitted by a different responder. This IFR type not only acknowledges to the transmitter that the message was transmitted successfully, but also reveals which receivers actually received the message. As with the Type 1 IFR, no CRC byte is appended to the end of a Type 2 IFR.

This IFR type is typically used with Function-type messages, where the original transmitter may need to know which nodes actually received the message. The basic difference between this type of IFR and the Type 1 IFR is that the nodes which lose arbitration while attempting to transmit their node ID during a Type 2 IFR wait until the byte which wins arbitration is transmitted and then again attempt to transmit their node ID onto the bus. The result is a series of node IDs, one from each receiver of the original message.

- IFR Type 3: Multiple Bytes from a Single Responder

  The last type of IFR defined by SAE J1850 is the Type 3 IFR. This IFR type consists of one or more bytes from a single responder. This type of IFR is used to return data to the original transmitter within the original message frame. This type of IFR may or may not have a CRC byte appended to it.

  The Type 3 IFR is typically used with Function Read-type or Function Query-type messages, where the original transmitter is requesting data from the intended receiver. The node requesting the data transmits the initial portion of the message, and the intended receiver responds by transmitting the desired data in an IFR. In most cases, the original message requiring a Type 3 IFR is addressed to one particular node, so no arbitration should take place during the IFR portion of the message.

### 20.8.6.2 BDLC IFR Transmit Control Bits

The BDLC module has three bits which are used to control the transmission of an In-Frame Response. These bits, all located in BDLC Control Register 2, are TSIFR, TMIFR1 and TMIFR0. Each is used in conjunction with the TEOD bit to transmit one of three IFR types defined in SAE J1850. What follows is a brief description of each bit.

Because each of the bits used for transmitting an IFR with the BDLC module is used to transmit a particular type of IFR, only one bit should be set by the CPU at a time. However, should more than one of these bits get set at one time, a priority encoding scheme is used to determine which type of IFR is sent. This scheme prevents unpredictable operation caused by conflicting signals to the BDLC module. Table 20-22 illustrates which IFR bit will actually be acted upon by the BDLC module should multiple IFR bits get set at the same time.

**NOTE**

As with transmitted messages, IFRs transmitted by the BDLC module will also be received by the BDLC module. For a description of how IFR bytes received by the BDLC module should be handled, refer to Section 20.8.7, “Receiving An In-Frame Response (IFR)”.

**Table 20-22. IFR Control Bit Priority Encoding**

| READ/WRITE | | | ACTUAL | | |
|---|---|---|---|---|---|
| TSIFR | TMIFR1 | TMIFR0 | TSIFR | TMIFR1 | TMIFR0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | X | X | 1 | 0 | 0 |
| 0 | 1 | X | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 | 1 |

### 20.8.6.3 Transmit Single Byte IFR

The Transmit Single Byte IFR (TSIFR) bit in BDLC Control Register 2 is used to transmit Type 1 and Type 2 IFRs onto the SAE J1850 bus. If this bit is set after a byte is loaded into the BDLC Data Register, the BDLC module will attempt to send that byte, preceded by the appropriate Normalization Bit, as a single byte IFR without a CRC. If arbitration is lost, the BDLC module will automatically attempt to transmit the byte again (without a Normalization Bit) as soon as the byte winning arbitration completes transmission. Attempts to transmit the byte will continue until either the byte is successfully transmitted, the TEOD bit is set by the user or an error is detected on the bus.

The user must set the TSIFR bit before the EOD following the main part of the message frame is received, or no IFR transmit attempts will be made for the current message. If another node does transmit an IFR to this message or a reception error occurs, the TSIFR bit will be cleared. If not, the IFR will be transmitted after the EOD of the next received message.

The TSIFR bit will be automatically cleared once the EOD following one or more IFR bytes has been received or an error is detected on the bus.

### 20.8.6.4 Transmit Multi-Byte IFR 1

The Transmit Multi-Byte IFR 1 (TMIFR1) bit is used to transmit an SAE J1850 Type 3 IFR with a CRC byte appended. If this bit is set after the user has loaded the first byte of a multi-byte IFR into the BDLC Data Register, the BDLC module will begin transmitting that byte, preceded by the appropriate Normalization Bit, onto the SAE J1850 bus. Once this happens a TDRE interrupt will occur, indicating to the user that the next IFR byte should be loaded into the BDLC Data Register. When the last byte to be transmitted is written to the BDLC Data Register, the user sets the TEOD bit. This will cause a CRC byte and an EOD symbol to be transmitted following the last IFR byte.

As with the TSIFR bit, the TMIFR1 bit must be set before the EOD symbol is received, or it will remain cleared and no IFR transmit attempt will be made. The TMIFR1 bit will be cleared once the CRC byte and EOD are transmitted, if an error is detected on the bus, if a loss of arbitration occurs during the IFR transmission or if a transmitter underrun occurs when the user fails to service the TDRE interrupt in a timely manner. If a loss of arbitration occurs while the Type 3 IFR is being transmitted, transmission will halt immediately and the loss of arbitration will be indicated in the BDLC State Vector Register.

### 20.8.6.5 Transmit Multi-Byte IFR 0

The Transmit Multi-Byte IFR 0 (TMIFR0) bit is used to transmit an SAE J1850 Type 3 IFR without a CRC byte appended. If this bit is set after the user has loaded the first byte of a multi-byte IFR into the BDLC Data Register, the BDLC module will begin transmitting that byte, preceded by the appropriate Normalization Bit, onto the SAE J1850 bus. Once this happens a TDRE interrupt will occur, indicating to the user that the next IFR byte should be loaded into the BDLC Data Register. When the last byte to be transmitted is written to the BDLC Data Register, the user sets the TEOD bit. This will cause an EOD symbol to be transmitted following the last IFR byte.

As with the TSIFR and TMIFR1 bits, the TMIFR0 bit must be set before the EOD symbol is received, or it will remain cleared and no IFR transmit attempt will be made. The TMIFR0 bit will be cleared once the CRC byte and EOD are transmitted, if an error is detected on the bus, if a loss of arbitration occurs during the IFR transmission or if a transmitter underrun occurs when the user fails to service the TDRE interrupt in a timely manner. If a loss of arbitration occurs while the Type 3 IFR is being transmitted, transmission will halt immediately and the loss of arbitration will be indicated in the BDLC State Vector Register.

**NOTE**

The TMIFR0 bit should not be used to transmit a Type 1 IFR. If a loss of arbitration occurs on the last bit of a byte being transmitted using the TMIFR0 bit, two extra logic ones will be transmitted to ensure that the IFR will not end on a byte boundary. This can cause an error in a Type 1 IFR.

### 20.8.6.6 Transmitting An IFR with the BDLC module

While the design of the BDLC module makes the transmission of each type of IFR similar, the steps necessary for sending each will be discussed. Again, a discussion of the bytes making up any particular IFR is not within the scope of this document. For a more detailed description of the use of IFRs on an SAE J1850 network, refer to the SAE J1850 document.

- Transmitting a Type 1 IFR

  To transmit a Type 1 IFR, the user loads the byte to be transmitted into the BDLC Data Register and sets both the TSIFR bit and the TEOD bit. This will direct the BDLC module to attempt transmitting the byte written to the BDLC Data Register one time, preceded by the appropriate Normalization Bit. If the transmission is not successful, the byte will be discarded and no further transmission attempts will be made. For an illustration of the steps described below, refer to Figure 20-23.
- Step 1: Load the IFR Byte into the BDLC Data Register

  The user begins initiation of a Type 1 IFR by loading the desired IFR byte into the BDLC Data Register. If a byte has already been written into the BDLC Data Register for transmission as a new message, the user can simply write the IFR byte to the BDLC Data Register, replacing the previously written byte. This must be done before the first EOD symbol is received.
- Step 2: Set the TSIFR and TEOD Bits

  The final step in transmitting a Type 1 IFR with the BDLC module is to set the TSIFR and TEOD bits in BDLC Control Register 2. Setting both bits will direct the BDLC module to make one attempt at transmitting the byte in the BDLC Data Register as an IFR. If the byte is transmitted successfully, or if an error or loss of arbitration occurs, TEOD and TSIFR will be cleared and no further transmit attempts will be made.

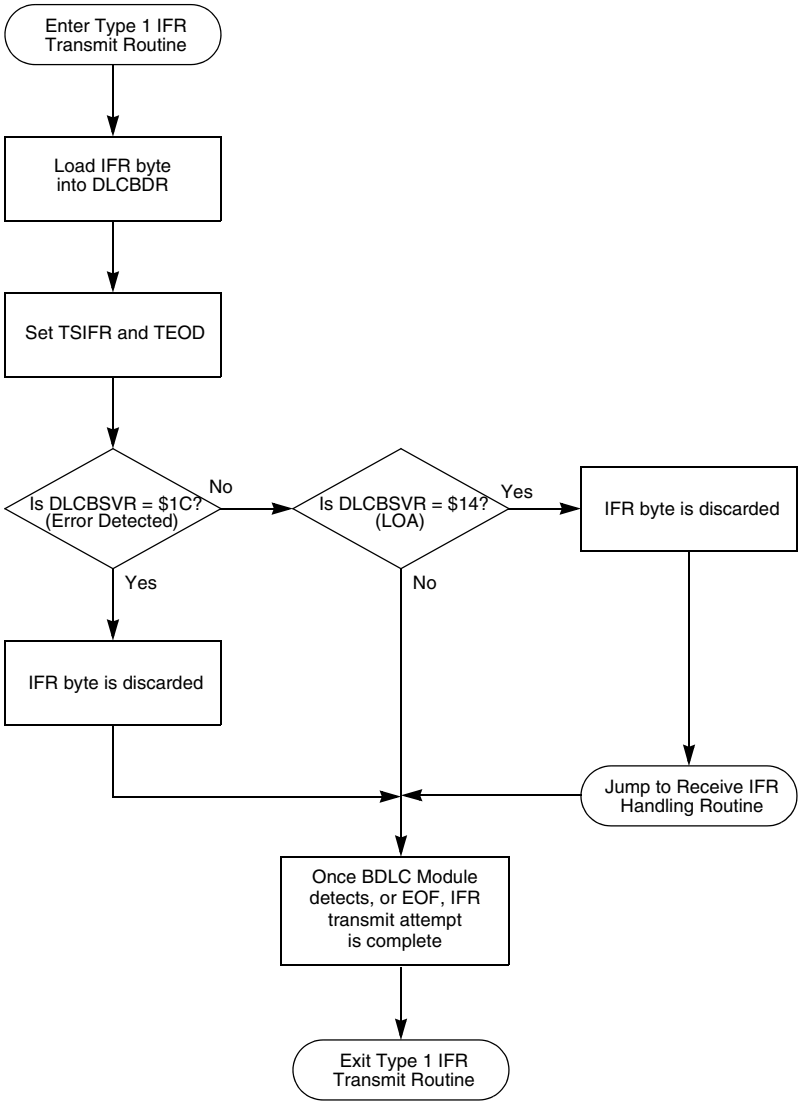

Enter Type 1 IFR Transmit Routine
Load IFR byte into DLCBDR
Set TSIFR and TEOD
Is DLCBSVR = $1C? (Error Detected)
No
Is DLCBSVR = $14? (LOA)
Yes
IFR byte is discarded
Yes
No
IFR byte is discarded
Jump to Receive IFR Handling Routine
Once BDLC Module detects, or EOF, IFR transmit attempt is complete
Exit Type 1 IFR Transmit Routine

**Figure 20-23. Transmitting A Type 1 IFR**

- Transmitting a Type 2 IFR

  To transmit a Type 2 IFR, the user loads the byte to be transmitted into the BDLC Data Register and sets the TSIFR bit. Once this is done, the BDLC module will attempt to transmit the byte in the BDLC Data Register as a single byte IFR, preceded by the appropriate Normalization Bit. If the first BDLC module loses arbitration on the first attempt, it will make repeated attempts to transmit this byte until it is successful, an error occurs or the user sets the TEOD bit.

  — Step 1: Load the IFR Byte into the BDLC Data Register

  As with the Type 1 IFR, the user begins initiation of a Type 2 IFR by loading the desired IFR byte into the BDLC Data Register. If a byte has already been written into the BDLC Data Register for transmission as a new message, the user can simply write the IFR byte to the BDLC Data Register, replacing the previously written byte. This must be done before the first EOD symbol is received.

— Step 2: Set the TSIFR Bit

The second step necessary for transmitting a Type 2 IFR is to set the TSIFR bit in BDLC Control Register 2. Setting this bit will direct the BDLC module to attempt to transmit the byte in the BDLC Data Register as an IFR until it is successful. If the byte is transmitted successfully, or if an error or loss of arbitration occurs, TSIFR will be cleared and no further transmit attempts will be made.

— Step 3: If Necessary, Set the TEOD Bit

The third step in transmitting a Type 2 IFR is only necessary if the user wishes to halt the transmission attempts. This may be necessary if the BDLC module's attempt to transmit the byte loaded into the BDLC Data Register continually loses arbitration, and the overall message length approaches the 12-byte limit as defined in SAE J1850.

If it becomes necessary to halt the IFR transmission attempts, the user simply sets the TEOD bit in BDLC Control Register 2. If the BDLC module is between transmission attempts, it will make one more attempt to transmit the IFR byte. If it is transmitting the byte when TEOD is set, the BDLC module will continue the transmission until it is successful or it loses arbitration to another transmitter. At this point it will then discard the byte and make no more transmit attempts.

**NOTE**

When transmitting a Type 2 IFR, the user should monitor the number of IFR bytes received to ensure that the overall message length does not exceed the 12-byte limit for the length of SAE J1850 messages. The user should set the TEOD bit when the 11th byte is received, which will prevent the 12-byte limit from being exceeded.

- Transmitting a Type 3 IFR

Transmitting a Type 3 IFR, with or without a CRC byte, is done in a fashion similar to transmitting a message frame. The user loads the first byte to be transmitted into the BDLC Data Register and then sets the appropriate TMIFR bit, depending upon whether a CRC byte is desired. When the last byte is written to the BDLC Data Register, the TEOD bit is set, and a CRC byte (if desired) and an EOD are then transmitted. Because the two versions of the Type 3 IFR are transmitted identically, the description which follows will discuss both. For an illustration of the Type 3 IFR transmit sequence, refer to Figure 20-25.

— Step 1: Load the First IFR Byte into the BDLC Data Register

The user begins initiation of a Type 3 IFR, as with each of the other IFR types, by loading the desired IFR byte into the BDLC Data Register. If a byte has already been written into the BDLC Data Register for transmission as a new message, the user can simply write the first IFR byte to the BDLC Data Register, replacing the previously written byte. This must be done before the first EOD symbol is received.

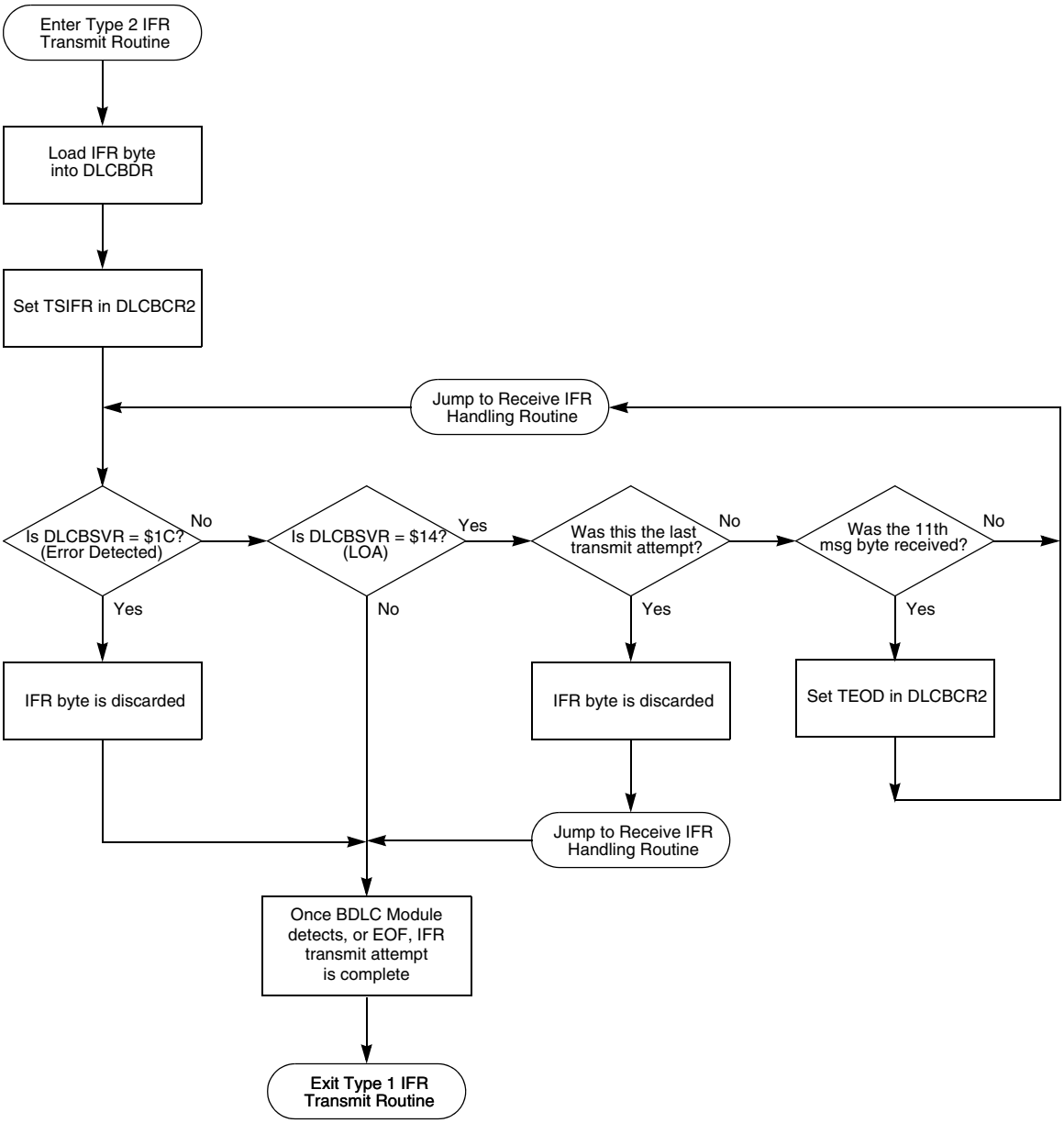

Enter Type 2 IFR Transmit Routine
Load IFR byte into DLCBDR
Set TSIFR in DLCBCR2
Jump to Receive IFR Handling Routine
Is DLCBSVR = $1C? (Error Detected)
No
Yes
Is DLCBSVR = $14? (LOA)
Yes
No
Was this the last transmit attempt?
No
Yes
Was the 11th msg byte received?
No
Yes
IFR byte is discarded
IFR byte is discarded
Set TEOD in DLCBCR2
Jump to Receive IFR Handling Routine
Once BDLC Module detects, or EOF, IFR transmit attempt is complete
Exit Type 1 IFR Transmit Routine

**Figure 20-24. Transmitting A Type 2 IFR**

— Step 2: Set the TMIFR Bit

The second step necessary for transmitting a Type 3 IFR is to set the desired TMIFR bit in BDLC Control Register 2, depending upon whether or not a CRC is desired. As previously described in Section 20.8.6.2, “BDLC IFR Transmit Control Bits”, the TMIFR1 bit should be set if the user requires a CRC byte to be appended following the last byte of the Type 3 IFR, and TMIFR0 if no CRC byte is required.

Setting the TMIFR1 or TMIFR0 bit will direct the BDLC module to transmit the byte in the BDLC Data Register as the first byte of a single or multi-byte IFR preceded by the appropriate

Normalization Bit. Once this has occurred, the BDLC State Vector Register will reflect that the next byte of the IFR can be written to the BDLC Data Register (TDRE interrupt).

**NOTE**

The user must set the TMIFR1 or TMIFR0 bit before the EOD following the main part of the message frame is received, or no IFR transmit attempts will be made for the current message. If another node does transmit an IFR to this message or a reception error occurs, the TMIFR1 or TMIFR0 bit will be cleared. If not, the IFR will be transmitted after the EOD of the next received message.

— Step 3: When TDRE is Indicated, Write the Next IFR Byte into the BDLC Data Register
When a TDRE state is reflected in the BDLC State Vector Register, the CPU writes the next IFR byte to be transmitted into the BDLC Data Register, clearing the TDRE interrupt. This step is repeated until the last IFR byte to be transmitted is written to the BDLC Data Register.

**NOTE**

As when transmitting a message, when transmitting a Type 3 IFR the user may write two, or possibly even three of the bytes to be transmitted into the BDLC Data Register before the first RxIFR interrupt occurs. For this reason, the user should never use receive IFR byte interrupts to control the sequencing of IFR bytes to be transmitted.

— Step 4: Write the Last IFR Byte into the BDLC Data Register and Set TEOD
Once the last IFR byte to be transmitted is written to the BDLC Data Register, the CPU then sets the TEOD bit in BDLC Control Register 2. Once the TEOD bit is set, after the last IFR byte written to the BDLC Data Register is transmitted onto the bus, if the TMIFR1 bit has been set the BDLC module will begin transmitting the CRC byte, followed by an EOD. If the TMIFR0 bit has been set, the last IFR byte will immediately be followed by the transmission of an EOD. Following the EOD, and EOF will be recognized and the message will be complete.

If at any time during the transmission of a Type 3 IFR a loss of arbitration occurs, the TMIFR bit which is set and the TEOD bit (if set) will be cleared, any IFR byte being transmitted will be discarded and the loss of arbitration state will be reflected in the BDLC State Vector Register. Likewise, if an error is detected during the transmission of a Type 3 IFR the IFR control bits will be cleared, the byte being transmitted will be discarded and the BDLC State Vector Register will reflect the detected error.

**NOTE**

If the Type 3 IFR being transmitted is made up of a single byte, the appropriate TMIFR bit and the TEOD bit can be set at the same time. The BDLC module will then treat that byte as both the first and last IFR byte to be sent.

### 20.8.6.7 Transmitting IFR Exceptions

This basic IFR transmitting flow can be interrupted for the same reasons as a normal message transmission. The IFR transmit process can be adversely affected due to a loss of arbitration, an Invalid or Out of Range

Symbol, or due to a transmitter underrun caused by the CPU failing to service a TDRE interrupt in a timely fashion. For a description of how these exceptions can affect the IFR transmit process, refer to Section 20.8.4.2, “Transmitting Exceptions”.

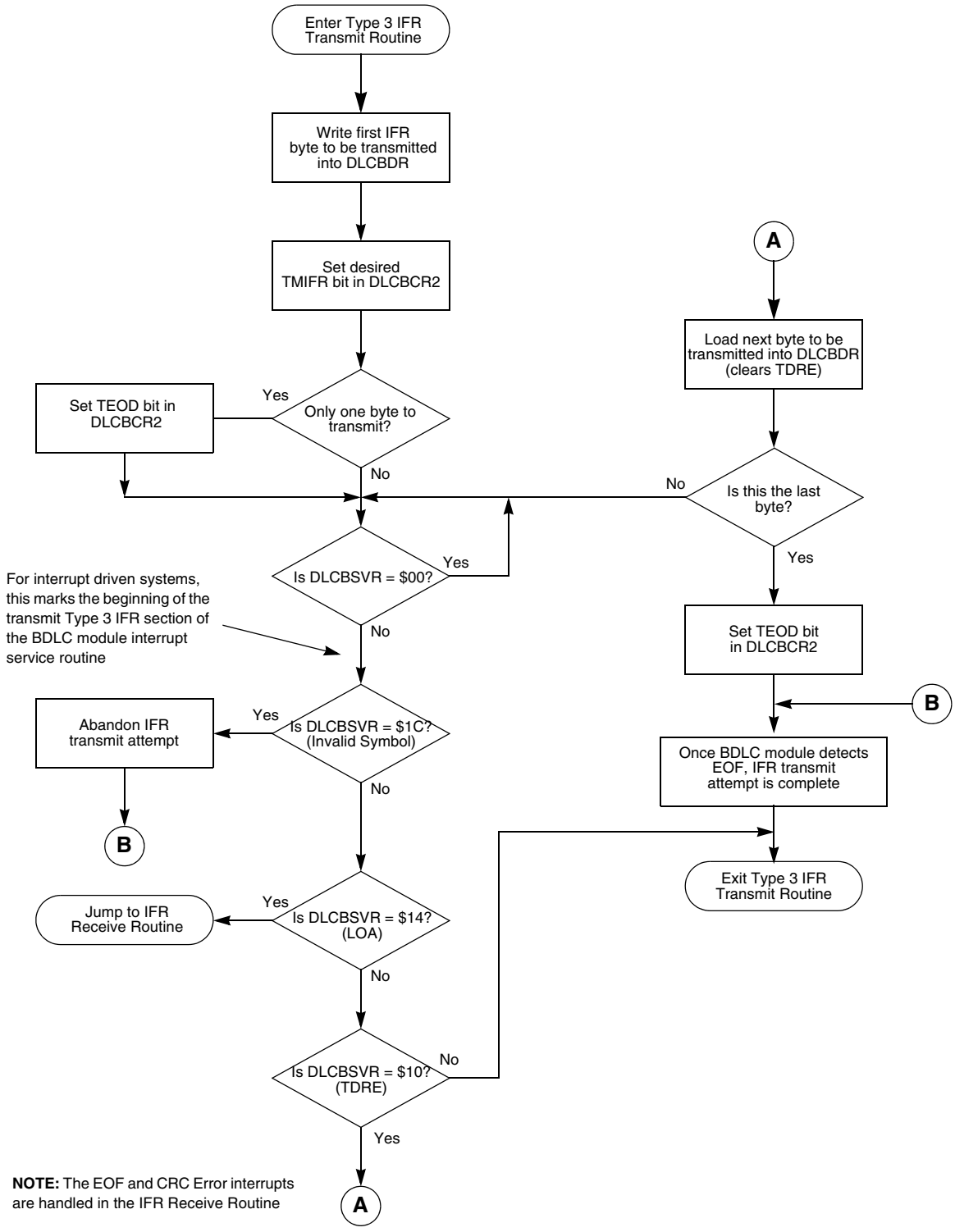

Enter Type 3 IFR Transmit Routine
Write first IFR byte to be transmitted into DLCBDR
Set desired TMIFR bit in DLCBCR2
Only one byte to transmit?
Yes
Set TEOD bit in DLCBCR2
No
Is DLCBSVR = $00?
Yes
No
For interrupt driven systems, this marks the beginning of the transmit Type 3 IFR section of the BDLC module interrupt service routine
Is DLCBSVR = $1C? (Invalid Symbol)
Yes
Abandon IFR transmit attempt
B
No
Is DLCBSVR = $14? (LOA)
Yes
Jump to IFR Receive Routine
No
Is DLCBSVR = $10? (TDRE)
No
Yes
A
NOTE: The EOF and CRC Error interrupts are handled in the IFR Receive Routine
A
Load next byte to be transmitted into DLCBDR (clears TDRE)
Is this the last byte?
No
Yes
Set TEOD bit in DLCBCR2
B
Once BDLC module detects EOF, IFR transmit attempt is complete
Exit Type 3 IFR Transmit Routine

**Figure 20-25. Transmitting A Type 3 IFR**

## 20.8.7 Receiving An In-Frame Response (IFR)

Receiving an In-Frame Response with the BDLC module is very similar to receiving a message frame. As each byte of an IFR is received, the BDLC State Vector Register will indicate this to the CPU. An EOF indication in the BDLC State Vector Register indicates that the IFR (and message) is complete. Also, the IMSG bit can also be used to command the BDLC module to mask any further network activity from the CPU, including IFR bytes being received, until the next valid SOF is received.

**NOTE**

As with a message transmission, the IMSG bit should never be used to ignore the BDLC module's own IFR transmissions. This is again due to the BDLC State Vector Register bits being inhibited from updating until IMSG is cleared, preventing the CPU from detecting any IFR-related state changes which may be of interest.

### 20.8.7.1 Receiving an IFR with the BDLC module

Receiving an IFR from the SAE J1850 bus requires the same procedure that receiving a message does, except that as each byte is received the Received IFR Byte (RxIFR) state is indicated in the BDLC State Vector Register. All other actions are the same. For an illustration of the steps described below, refer to Figure 20-26.

- Step 1: When RxIFR Interrupt Occurs, Retrieve IFR Byte

  When the first byte of an IFR following a valid EOD symbol is received that byte is placed in the BDLC Data Register, and an RxIFR state is reflected in the BDLC State Vector Register. No indication of the EOD reception in made, since the RxIFR state will indicate that the main portion of the message has ended and the IFR portion has begun.

  The RxIFR interrupt is cleared when the received IFR byte is read from the BDLC Data Register. Once this is done, no further CPU intervention is necessary until the next IFR byte is received, and this step is repeated. As with a message reception, all bytes of the IFR, including the CRC byte, will be placed into the BDLC Data Register as they are received for the CPU to retrieve.
- When an EOF is Received, the IFR (and Message) is Complete

  Once all IFR bytes (including the possible CRC byte) have been received from the bus, the bus will again be idle for a time period equal to an EOD symbol. Following this, the BDLC module will determine whether or not the last byte of the IFR is a CRC byte, and if so verify that the CRC byte is correct. If the CRC byte is not correct, this will be reflected in the BDLC State Vector Register.

  After an additional period of time the EOD symbol will transition into an EOF symbol. When the EOF is received it will be reflected in the BDLC State Vector Register, indicating to the user that the IFR, and the message, is complete.

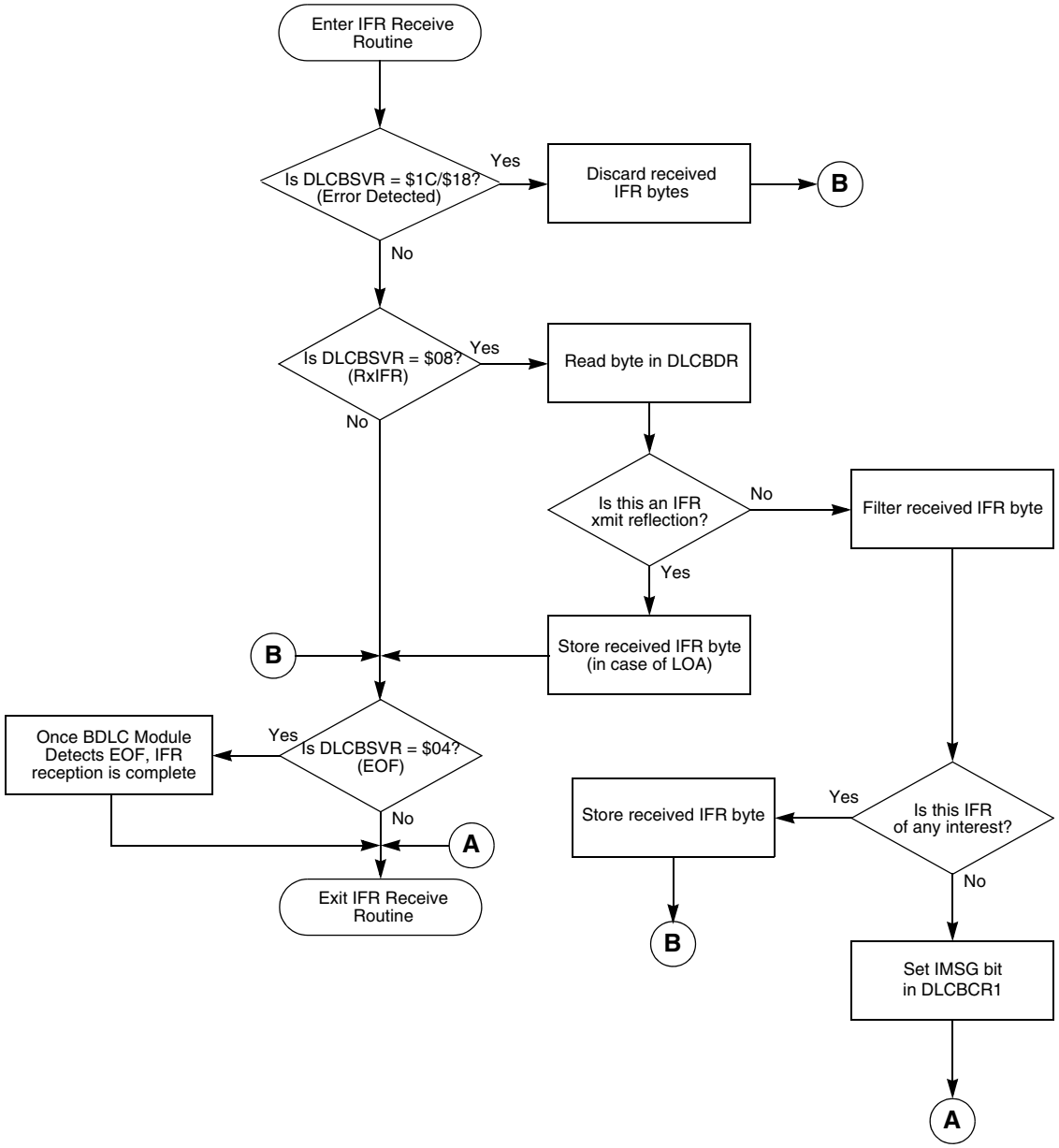



**Figure 20-26. Receiving An IFR With the BDLC Module**

#### 20.8.7.2 Receiving IFR Exceptions

This basic IFR receiving flow can be interrupted for the same reasons as a normal message reception. The IFR receiving process can be adversely affected due to a CRC error, an Invalid or Out of Range Symbol or due to a receiver overrun caused by the CPU failing to service an RxIFR interrupt in a timely fashion. For a description of how these exceptions can affect the IFR receiving process, refer to Section 20.8.5.4, “Receiving Exceptions”.

### 20.8.8 Special BDLC Module Operations

There are a few special operations which the BDLC module can perform. What follows is a brief description of each of these functions and when they might be used.

#### 20.8.8.1 Transmitting Or Receiving A Block Mode Message

The BDLC module, because it handles each message on a byte-by-byte basis, has the inherent capability of handling messages any number of bytes in length. While during normal operation this requires the user to carefully monitor message lengths to ensure compliance with SAE J1850 message limits, often in a production or diagnostic environment messages which exceed the SAE J1850 limits can be beneficial. This is especially true when large amounts of configuration data need to be downloaded over the SAE J1850 network.

Because of the BDLC module’s architecture, it can both transmit and receive messages of unlimited length. The CRC calculations, both for transmitting and receiving, are not limited to eight bytes, but will instead be calculated and verified using all bytes in the message, regardless of the number. All control bits, including TEOD and IMSG, also work in an identical manner, regardless of the length of the message.

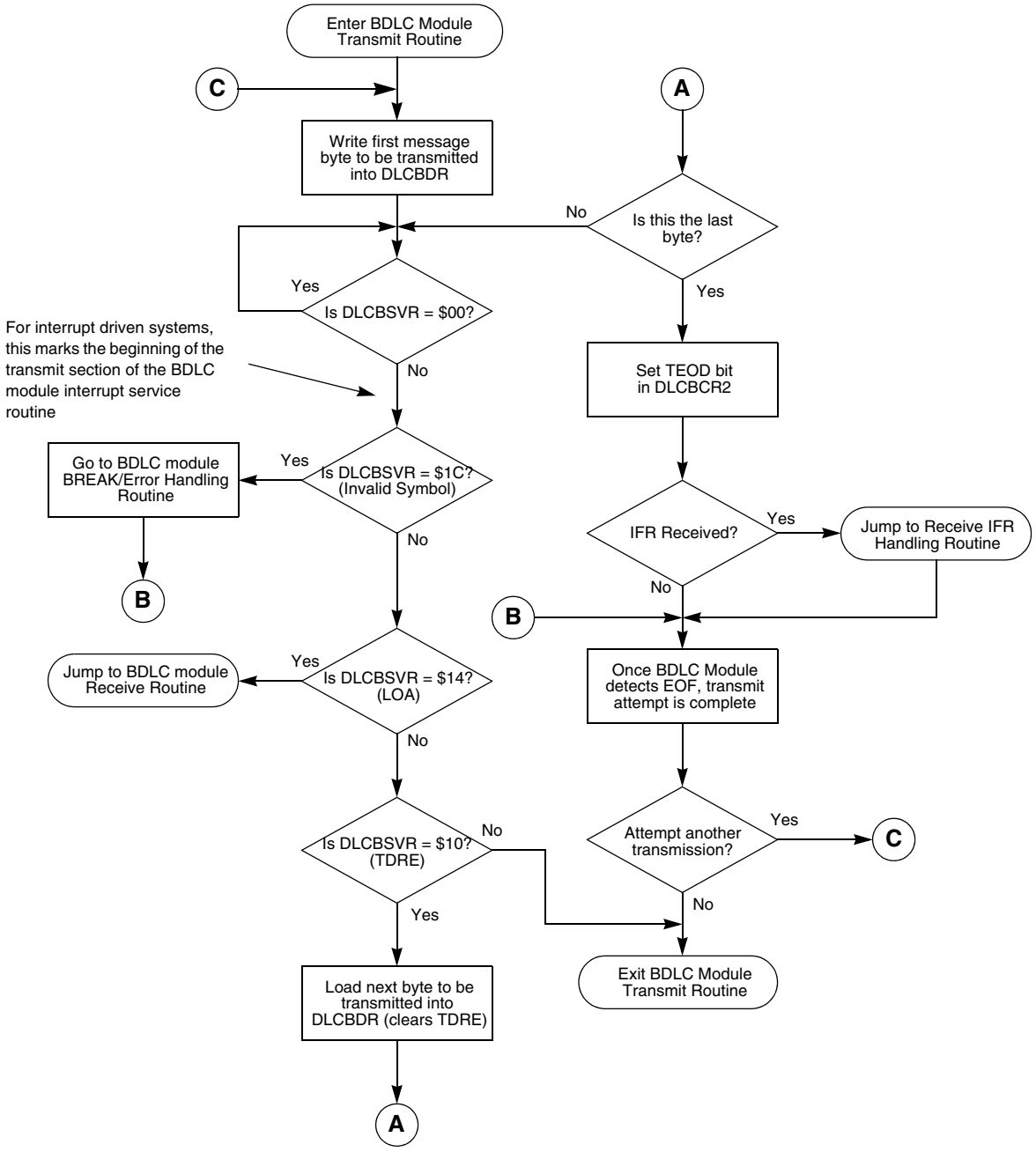
To transmit or receive these “Block Mode” messages, no extra BDLC module control functions must be performed. The user simply transmits or receives as many bytes as desired in one message frame, and the BDLC module will operate just as if a message of normal length was being used.

#### 20.8.8.2 Transmitting Or Receiving A Message In 4X Mode

In a diagnostic or production environment large amounts of data may need to be downloaded across the network to a component or module. This data is often sent in a large “Block Mode” message (see above) which violates the SAE J1850 limit for message length. In order to speed up the downloading of these large blocks of data, they are sometimes transmitted at four times (4X) the normal bit rate for the Variable Pulse Width modulation version of SAE J1850. This higher speed transmission, nominally 41.6kbps, allows these large blocks to be transmitted much more quickly.

The BDLC module is designed to receive and transmit messages at this higher speed. By setting the 4XE bit in BDLC Control Register 2, the user can command the BDLC module to transmit and receive any message over the network at a 4X rate.

If the BDLC module is placed in this 4X mode, messages transmitted at the normal bit rate will not be received correctly. Likewise, 4X messages transmitted on the SAE J1850 bus when the BDLC module is in normal mode will be interpreted as noise on the network by the BDLC module. For more information on the 4XE bit, refer to Section • 4X Mode.




**NOTE:** The EOF and CRC Error interrupts are handled in the BDLC module Receive Routine

**Figure 20-27. Basic BDLC Module Transmit Flowchart**

## 20.8.9 BDLC Module Initialization

This section includes sample flows for initializing the BDLC module and using it to transmit and receive messages.

### 20.8.9.1 Initialization Sequence

To initialize the BDLC module, the user should first write the desired data to the configuration bits. The BDLC module should then be taken out of digital and analog loopback mode and enabled. Exiting from loopback mode will entail change of state indications in the BDLC State Vector Register which must be dealt with. Once this is complete, CPU interrupts can be enabled (if desired), and then the BDLC module is capable of SAE J1850 serial network communication. For an illustration of the sequence necessary for initializing the BDLC module, refer to Figure 20-28.

### 20.8.9.2 Initializing the Configuration Bits

The first step necessary for initializing the BDLC module following an MCU reset is to write the desired values to each of the BDLC module control registers. This is best done by storing predetermined initialization values directly into these registers. The following description outlines a basic flow for initializing the BDLC module. This basic flow does not detail more elaborate initialization routines, such as performing digital and analog loopback tests before enabling the BDLC module for SAE J1850 communication. However, from the following descriptions and the BDLC module specification, the user should be able to develop routines for performing various diagnostic procedures such as loopback tests.

- Step 1 - Initialize BDLC Analog Round Trip Delay Register

  Begin initialization of the configuration bits by writing the desired analog transceiver configuration data into the BDLC Analog Round Trip Delay Register. Following this write to BDLC Analog Round Trip Delay Register, all of these bits will become read only.
- Step 2- Initialize BDLC Baud Rate Select Register

  The next step in BDLC module initialization is to write the desired bus clock divisor minus one into the BDLC Baud Rate Select Register BDLC Baud Rate Select Register. The divisor should be chosen to generate a 1 MHz or 1.048576 MHz mux interface clock ($f_{bdlc}$). Following this write to BDLC Baud Rate Select Register, all of these bits will become read only.
- Step 3- Initialize BDLC Control Register 2

  The next step in BDLC module initialization should be writing the configuration bits into the BDLC Control Register 2 register. This initialization description assumes that the BDLC module will be put into normal mode (not 4X mode), and that the BDLC module should not yet exit either digital or analog loopback mode. Therefore, this step should write SMRST and DLOOP as logic ones, 4XE as a logic zero, write NBFS to the desired level, and write TEOD, TSIFR, TMIFR1 and TMIFR0 as logic zeros. These last four bits MUST be written as logic zeros in order to prevent undesired operation of the BDLC module.
- Step 4- Initialize BDLC Control Register 1

  The next step in BDLC module initialization is to write the configuration bits in BDLC Control Register 1. The CLKS bit should be written to its desired values at this time, following which it will become read-only. The IE bit should be written as a logic zero at this time so BDLC module interrupts of the CPU will remain masked for the time being. The IMSG bit should be written as a logic one to prevent any receive events from setting the BDLC State Vector Register until a valid SOF (or BREAK) symbol has been received by the BDLC module.

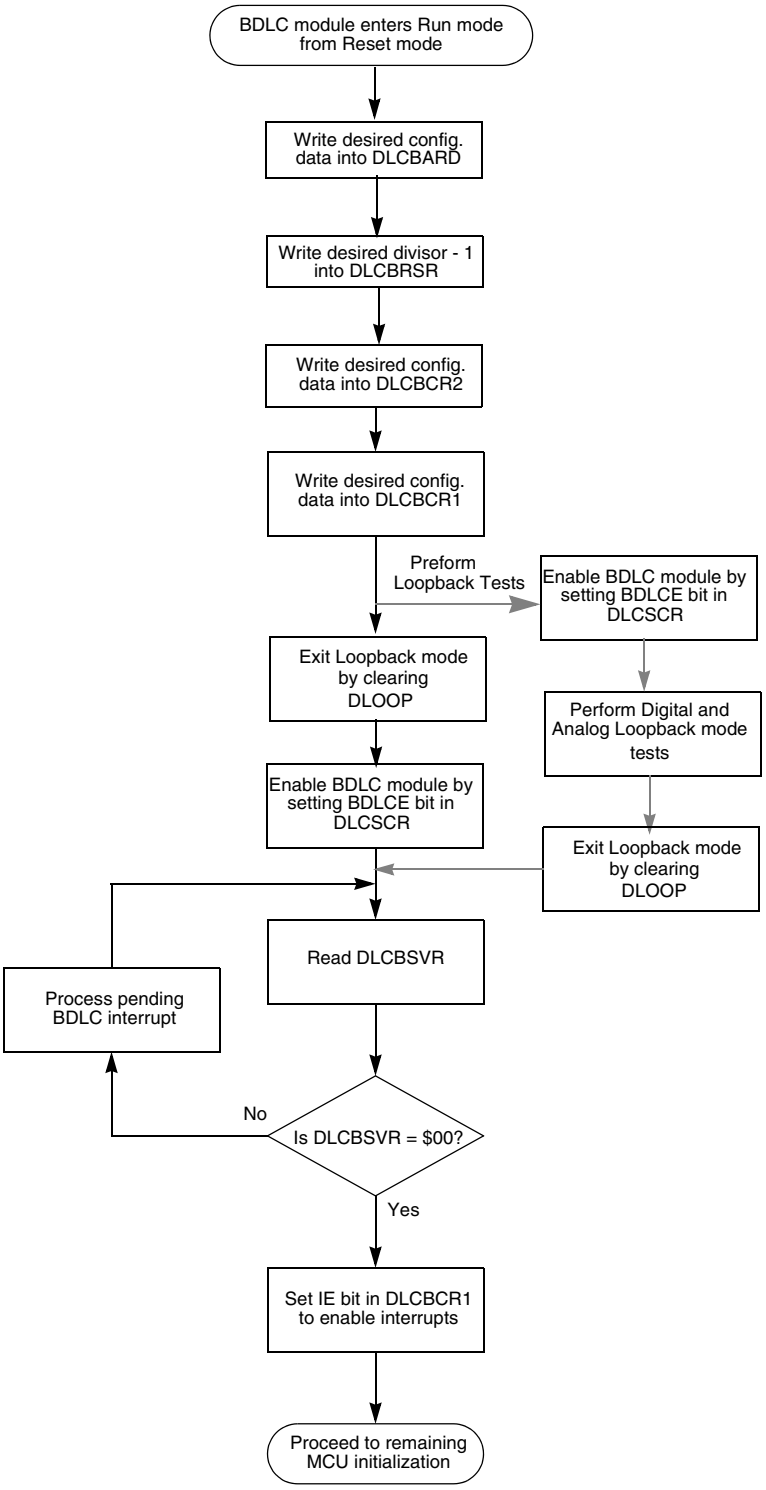

BDLC module enters Run mode from Reset mode
Write desired config. data into DLCBARD
Write desired divisor - 1 into DLCBRSR
Write desired config. data into DLCBCR2
Write desired config. data into DLCBCR1
Preform Loopback Tests
Enable BDLC module by setting BDLCE bit in DLCSCR
Perform Digital and Analog Loopback mode tests
Exit Loopback mode by clearing DLOOP
Exit Loopback mode by clearing DLOOP
Enable BDLC module by setting BDLCE bit in DLCSCR
Read DLCBSVR
Process pending BDLC interrupt
No
Is DLCBSVR = $00?
Yes
Set IE bit in DLCBCR1 to enable interrupts
Proceed to remaining MCU initialization

**Figure 20-28. Basic BDLC Module Initialization Flowchart**

### 20.8.9.3 Exiting Loopback Mode and Enabling the BDLC module

Once the configuration bits have been written to the desired values, the BDLC module should be taken out of loopback and connected to the SAE J1850 bus. This is done by clearing the DLOOP bit and then setting the BDLCE bit in the BDLC Control Register.

- Step 5- Perform Loopback Tests (optional)

  Once the BDLC module is configured for desired operation, the user may wish to perform digital and/or analog loopback tests to determine the integrity of the link to the SAE J1850 network. This would involve leaving the DLOOP bit (BDLC Control Register 2) set, setting the BDLCE bit, preforming the desired loopback tests and finally exiting digital loopback mode by clearing DLOOP in the BDLC Control Register 2.
- Step 6- Exit Loopback Mode and enable the BDLC module

  If loopback mode tests are not to be preformed the BDLC module can be removed from digital loopback mode by clearing the DLOOP bit. The BDLC module can then be enabled by setting the BDLCE bit in the BDLC Control Register.

  Once DLOOP is cleared and BDLCE is set, the BDLC module is ready for SAE J1850 communication. However, to ensure that the BDLC module does not attempt to receive a message already in progress or to transmit a message while another device is transmitting, the BDLC module must first observe an EOF symbol on the bus before the receiver will be activated. To activate the transmitter, the BDLC module will need to observe an Inter-Frame Separator symbol.

### 20.8.9.4 Enabling BDLC Interrupts

The final step in readying the BDLC module for proper communication is to clear any pending interrupt sources and then, if desired, enable BDLC module interrupts of the CPU.

- Step 7- Clear Pending BDLC Interrupts

  In order to ensure that the BDLC module does not immediately generate a CPU interrupt when interrupts are enabled, the user should read the BDLC State Vector Register to determine if any BDLC module interrupt sources are pending before setting the IE bit in the BDLC Control Register 1. If the BDLC State Vector Register reads as a %00000000, no interrupts are pending and the user is free to enable BDLC interrupts, if desired.

  If the BDLC State Vector Register indicates that an interrupt is pending, the user should perform whatever actions are necessary to clear the interrupt source before enabling the interrupts. Whether any interrupts are pending will depend primarily upon how much time passes between the exit from loopback modes and enabling the BDLC module and the enabling of interrupts. It is a good practice to always clear any source of interrupts before enabling interrupts on any MCU subsystem.

  If any interrupts are pending (BDLC State Vector Register not %00000000), then each interrupt source should be dealt with accordingly. Once all of the interrupt sources have been dealt with, the BDLC State Vector Register should read %00000000, and the user is then free to enable BDLC interrupts.
- Step 8- Enable BDLC Interrupts

  The last step in initializing the BDLC module is to enable interrupts to the CPU, if so desired. This is done by simply setting the IE bit in the BDLC Control Register 1. Following this, the BDLC module is ready for operating in interrupt mode. If the user chooses not to enable interrupts, the

BDLC State Vector Register must be polled periodically to ensure that state changes in the BDLC module are detected and dealt with appropriately.

## 20.9 Resets

### 20.9.1 General

The reset state of each individual bit is listed within Section 20.7, “Memory Map and Registers” which details the registers and their bit-fields.

# Chapter 21
# Debug Support and JTAG Interface

## 21.1 Overview

The following sections are contained in this document:

- Section 21.2, “TAP Link Module (TLM) and Slave TAP Implementation”
- Section 21.3, “TLM and TAP Signal Descriptions”
- Section 21.4, “Slave Test Reset (STRST)”
- Section 21.5, “TAP State Machines”
- Section 21.6, “e300 Core JTAG/COP Serial Interface”
- Section 21.7, “TLM Link DR Instructions”
- Section 21.8, “TLM Test Instructions” includes:
  - Section 21.8.1, “IDCODE”
  - Section 21.8.1.1, “Device ID Register”
- Section 21.9, “e300 COP/BDM Interface”

The MPC5200B provides the user an IEEE 1149.1 JTAG interface to facilitate board/system testing. It also provides a Common On-Chip Processor (COP) Interface, which shares the IEEE 1149.1 JTAG port. The COP Interface provides access to the MPC5200B's imbedded Freescale MPC603e G2_LE processor. This interface provides a means for executing test routines and for performing software development & debug functions.

## 21.2 TAP Link Module (TLM) and Slave TAP Implementation

The MPC5200B debug and development logic consists of:

- A master TAP Link Module (TLM), which implements the mandatory instructions of the IEEE JTAG 1149.1 standard.
- A slave JTAG TAP block dedicated to microprocessor debug functions, which are contained within the imbedded e300 microprocessor.

The master/slave TLM/TAP architecture is not yet an approved extension of the IEEE standard. It is, however, interface-compatible with the standard.

The TLM state machine is active at all times.

The TLM and slave TAP blocks each consist of:

- A TAP Controller state machine
- Instruction Register (IR)
- Instruction decode
- Various Data Registers (DR)

There is no inherent limit to the number of slave TAP blocks. However, no more than one slave TAP Controller state machine, designated by its asserted Enable, is active at any time. The slave TAP state machines have an Enable input and a Select output not present in the IEEE standard.

- All slave Enable signals are generated by the TLM block. No more than one Enable signal is ever asserted at one time.
- All slave Select signals are inputs to the TLM block. Any number of Select signals may be asserted at any time.

The TLM block contains a Link DR that determines which, if any, slave TAP block is active.

- When a slave TAP block is inactive, its TAP Controller state machine is locked in the RunTestIdle state, preventing its IR and DRs from shifting.
- When a slave TAP block is active, the TLM IR and DRs (except the TLM Link DR described below) are disabled. However, the TLM state machine continues to respond to the TAP interface signals TRST, TCK, and TMS.

The TLM Link DR can be shifted while a slave TAP is active. This is done by loading the slave IR with an instruction that activates the Select signal, then performing a DR scan operation. This only affects the TLM Link DR, because the TLM IR selected the Link DR to enable a slave in the first place, and the TLM IR cannot change while a slave is active.

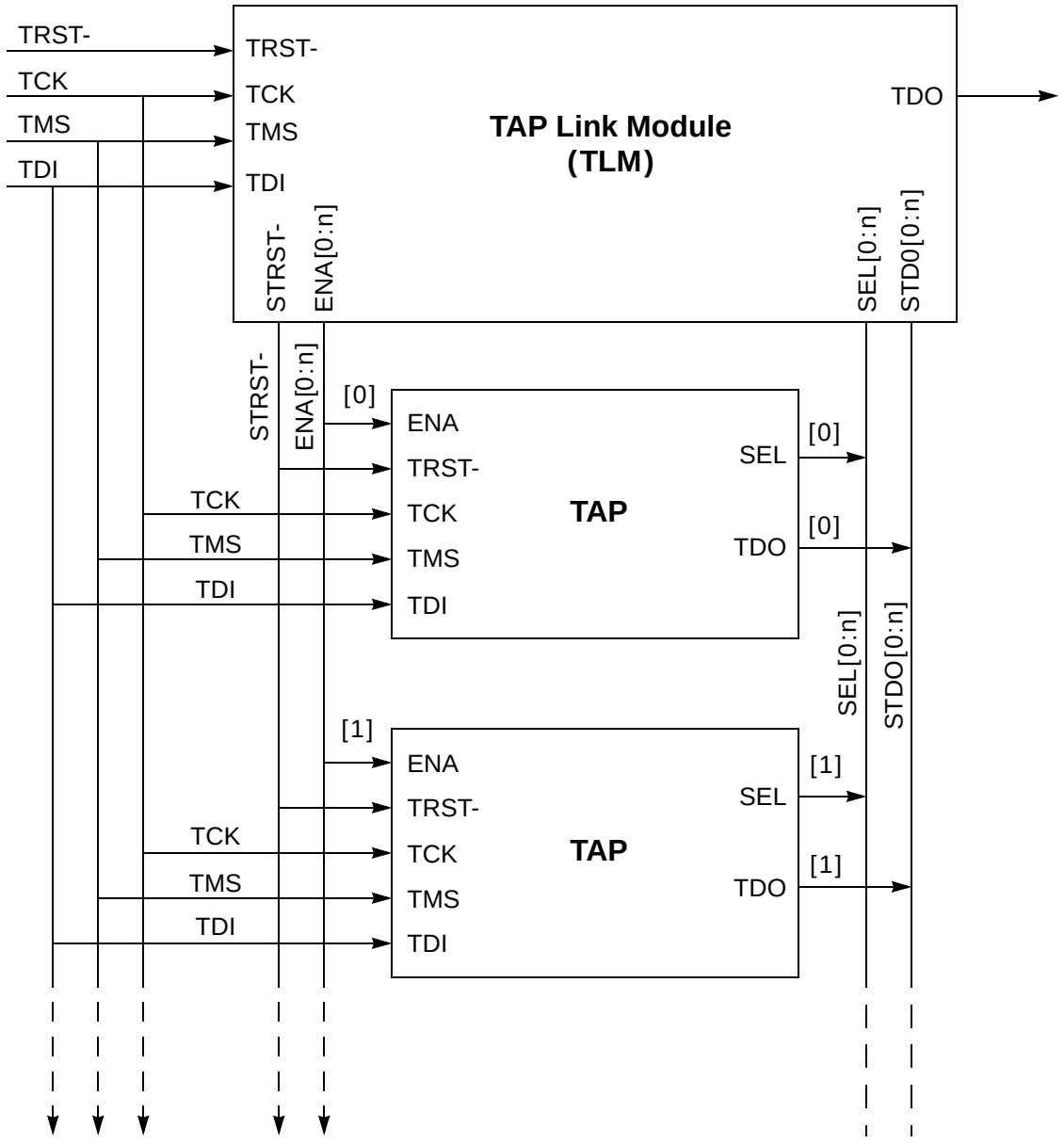



**Figure 21-1. Generic TLM/TAP Architecture Diagram**

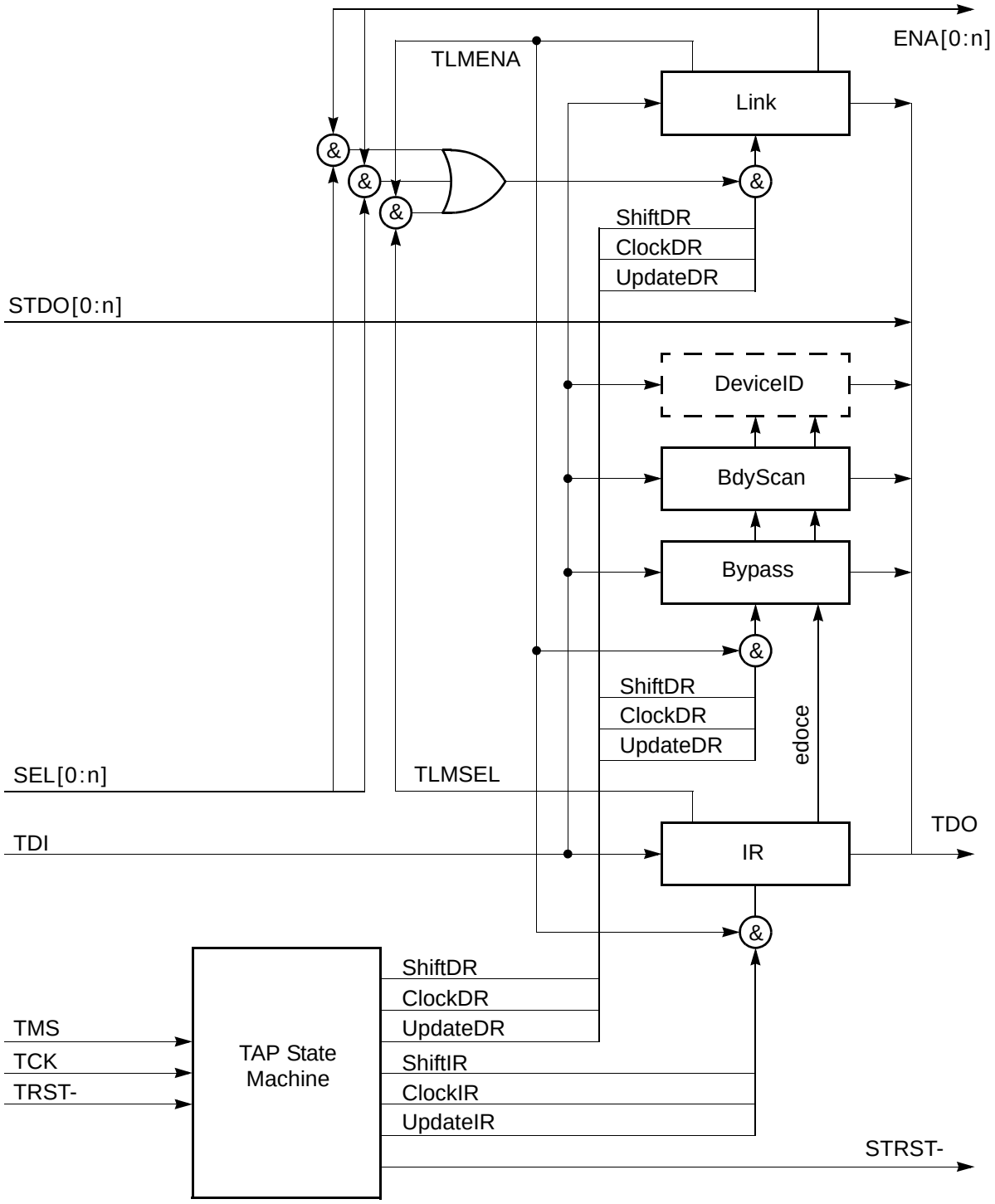



**Figure 21-2. Generic TAP Link Module (TLM) Diagram**

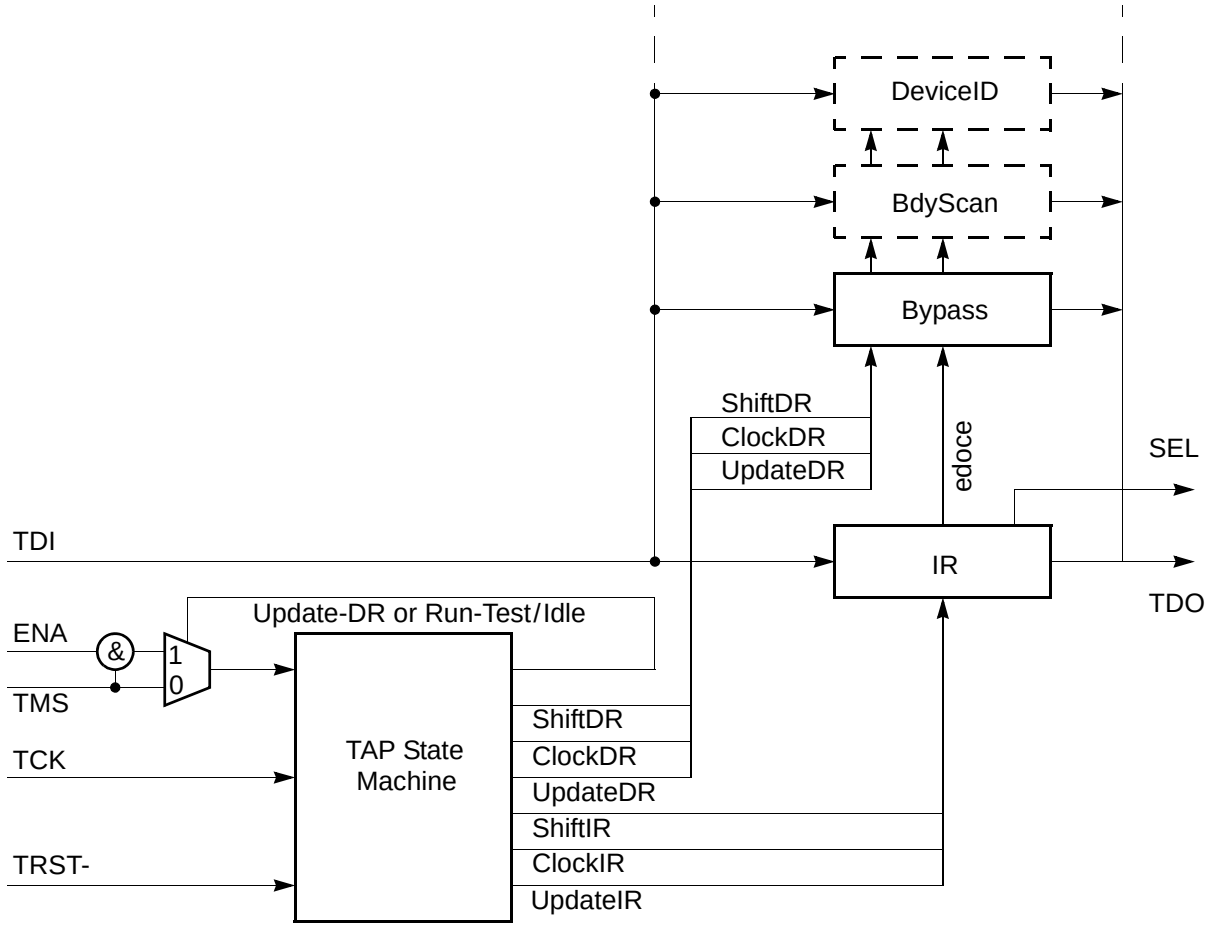



**Figure 21-3. Generic Slave TAP**

## 21.3 TLM and TAP Signal Descriptions

### 21.3.1 Test Reset (TRST)

JTAG reset, active low. When asserted, any on-going JTAG operation is immediately aborted. All TAP state machines, including the TLM, immediately enter the Test-Logic-Reset state. Other JTAG input signals (TCK, TMS, and TDI) have no effect while TRST is asserted. TDO is immediately tri-stated.

### 21.3.2 Test Clock (TCK)

This is the JTAG clock. The (non-reset) behavior of the active TAP and TLM state machines is governed by the TMS value at the TCK rising edge. TDI value is sampled at the TCK rising edge for all shift operations. All TDO non-reset transitions (including impedance) occur at the TCK falling edge. All shift register capture operations occur at the TCK rising edge. All shift register Update operations occur at the TCK falling edge.

### 21.3.3 Test Mode Select (TMS)

TAP state machine control, including TLM. The state of TMS at rising edges of TCK uniquely determines the state sequence of the TLM and the active TAP state machines. See Figure 21-4. Inactive TAPs ignore TMS completely.

### 21.3.4 Test Data In (TDI)

Serial test data input can be routed to any IR or DR, as determined by the state of the active TAP state machine and the contents of the active IR. TDI is sampled at the TCK rising edge while the active TAP state machine is in either the Shift-IR or Shift-DR state.

### 21.3.5 Test Data Out (TDO)

Serial test data output is routed from the active shift register to this pin. To ensure setup and hold time for TDO when connected to TDI (of another device), TDO switches at the TCK falling edge. TDO is driven while the TLM state machine is in the Shift-IR or Shift-DR states only; it is tri-stated in all other TAP states. Except, for the first half clock after exiting the shift state, because of its falling edge timing.

## 21.4 Slave Test Reset (STRST)

STRST is the active-low reset from the TLM to all slave TAP blocks. STRST is asserted whenever the TLM state machine is in the Test Logic Reset state. This is a result of TRST being asserted, or the TMS sequence.

### 21.4.1 Enable Slave—ENA[0:n]

Enable signals are decoded from the contents of the TLM:Link DR. There is one Enable signal for the TLM and one for each slave TAP block. No more than one Enable signal can be asserted at one time. Each slave TAP block gates (logical AND) TMS with a unique Enable signal. Any number of TLM:Link DR codes may activate any Enable signal. MPC5200B implements one TLM:Link DR code for each Enable signal.

### 21.4.2 Select DR Link—SEL[0:n]

Each slave TAP block generates one Select signal; its value is decoded from the contents of its IR. Any number of Select signals may be asserted at any time; the TLM ignores all SEL[0:n] signals except from the active slave TAP (if any). Instruction codes that activate Select may be different in each slave TAP block. Any number of instruction codes may activate Select, but the mandatory BYPASS, EXTEST, and SAMPLE:PRELOAD instructions (and IDCODE, if implemented) must not. However, a slave is allowed to implement additional instructions that behave identically to any of these instructions, except that Select is asserted and the normal DR is disabled.

### 21.4.3 Slave Test Data Out—STDO[0:n]

Each slave TAP block provides a serial test data output. Just like TDO, all transitions of STDO[0:n] must occur on the falling edge of TCK. ENA[0:n] and SEL[0:n] select either the active slave serial output data or the TLM serial output data to appear at the TDO pin.

## 21.5 TAP State Machines

All TAP state machines are the same, including the TLM, except for the single control signal. The TLM receives the external TMS signal unmodified; all other (slave) TAP Controllers respond to unique versions of TMS combined with their unique Enable signal.

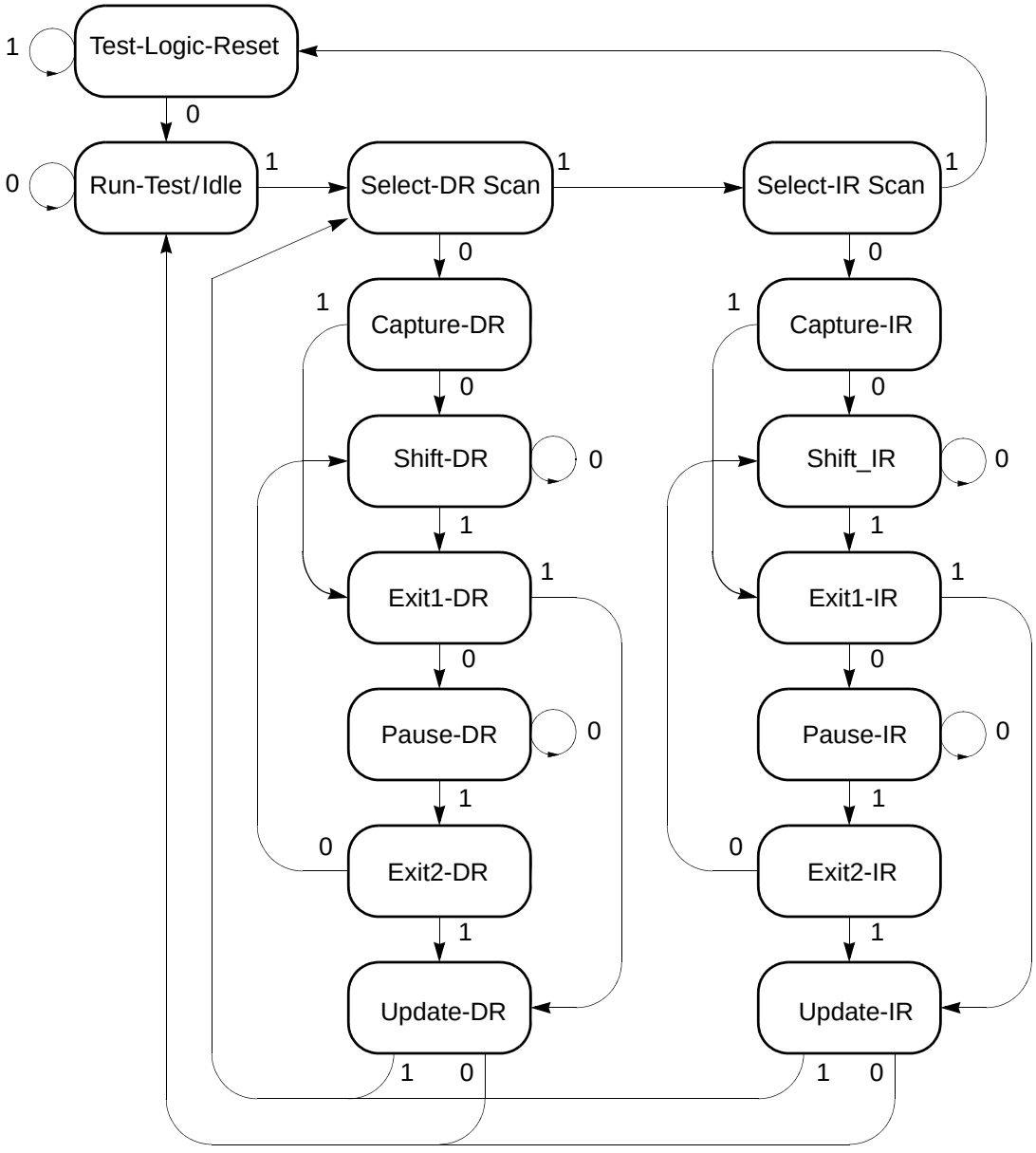



**Figure 21-4. State Diagram—TAP Controller**

Instructions are loaded by stepping the state machine to the Shift-IR state by applying an appropriate sequence of values on TMS at successive rising edges of TCK. Once in the Shift-IR state, TMS is held low and appropriate values are applied at TDI (lsb-first) at successive rising edges of TCK. As the last (ms) bit is applied at TDI, TMS is set high and the state machine is advanced through the Exit1-IR and Update-IR states. The instruction becomes effective at the falling edge of TCK in the Update-IR state.

Data registers are loaded by first selecting the desired data register with an appropriate instruction, then stepping the state machine to the Shift-DR state. Once in the Shift-DR state, TMS is held low and appropriate values are applied at TDI (lsb-first) at successive rising edges of TCK. As the last (ms) bit is applied at TDI, TMS is set high and the state machine is advanced through the Exit1-DR and Update-DR states. The data becomes effective at the falling edge of TCK in the Update-DR state.

## 21.6 e300 Core JTAG/COP Serial Interface

The Common On-chip Processor (COP) external interface adheres to the IEEE 1149.1 serial protocol. The COP uses the JTAG interface which includes a TAP Controller, a COP Controller, input and output multiplexors, registers, several shift register latches (SRLs) and a counter (RunN) which controls clock execution. All IEEE 1149.1 public instructions are implemented (SAMPLE_PRELOAD, BYPASS, and EXTEST). Figure 21-5 shows the components that make up the microprocessor JTAG/COP serial interface.

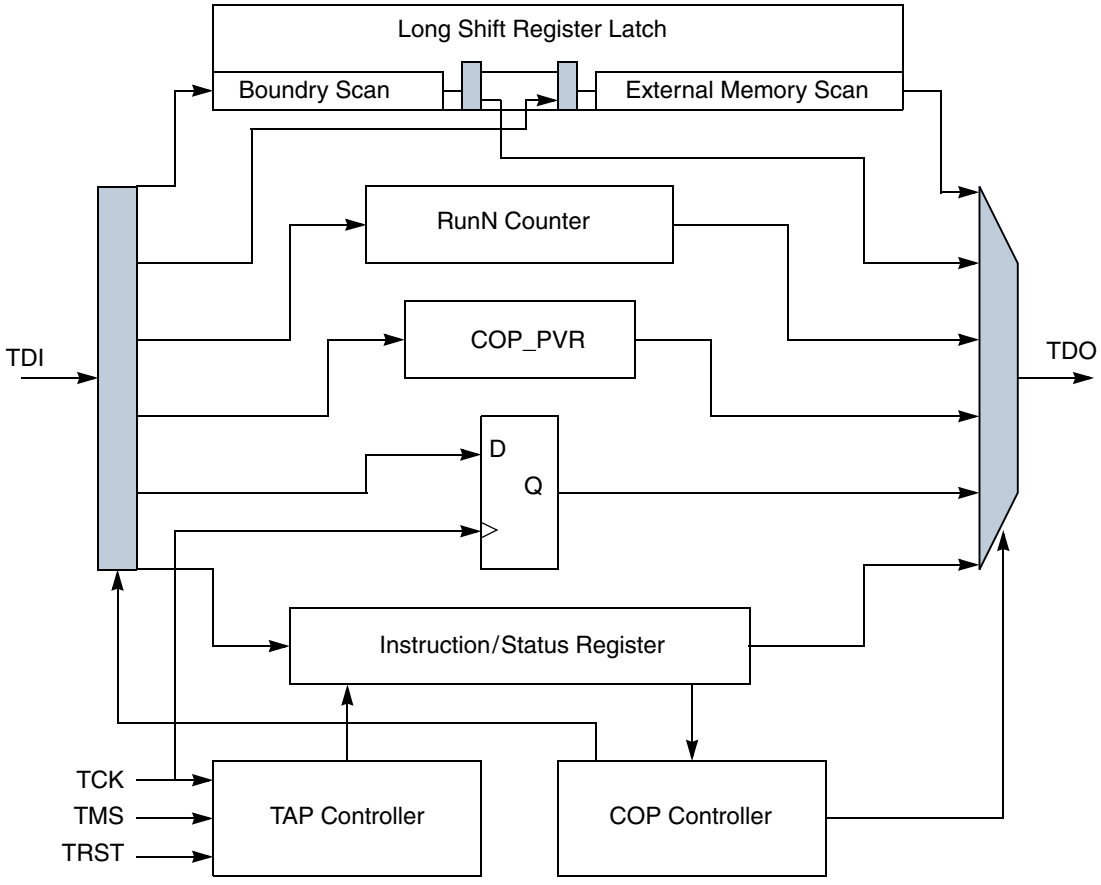



**Figure 21-5. e300 Core JTAG/COP Serial Interface**

## 21.7 TLM Link DR Instructions

**CAUTION**

1. For the following registers, only the instruction codes listed should be used. All other codes must be considered private and potentially damaging.
2. “Persistent” means an instruction’s effect(s) persist even after it is overwritten in the register.
3. The reset value shown is the update register reset value. Per the JTAG standard, the raw IR shift register reset value is irrelevant.

**Table 21-1. TLM Link-DR Instructions**

| Instruction | Encoding (ENA[1:0]) | Persistent |
|---|---|---|
| TLM:TLMENA | 01 | N[3] |
| TLM:PPCENA | 10 | N |

**Note:**

1. Reset = TLM:TLMENA
2. Capture = Current Value
3. Link Pseudo-instructions are persistent with respect to the enabled IR, but not with respect to the contents of the TLM:Link DR itself.

Link pseudo-instructions are loaded into the 2-bit TLM:Link DR when it is selected by instructions of the TLM or slave TAP blocks. The value shifted into the TLM:Link DR determines which IR will be active after the Update-DR state. The selection remains in effect until the TLM:Link register is selected again, and modified.

### 21.7.1 TLM:TLMENA

The TLM:TLMENA pseudo-instruction selects the 6-bit TLM IR.

### 21.7.2 TLM:PPCENA

The TLM:PPCENA pseudo-instruction selects the 8-bit microprocessor CPU test IR.

## 21.8 TLM Test Instructions

The TLM IR activates device-level functions, including the mandatory JTAG instructions and private device test data registers.

**Table 21-2. TLM Test Instruction Encoding**

| Instruction | Encoding | Persistent | TLM Register |
|---|---|---|---|
| IDCODE | 011101 | N | Device_ID |
| BYPASS | 111111 | N | Bypass |
| SAMPLE/PRELOAD | 100000 | N | Boundary |
| EXTEST | 000000 | N | Boundary |

**Table 21-2. TLM Test Instruction Encoding (continued)**

| Instruction | Encoding | Persistent | TLM Register |
|---|---|---|---|
| CLAMP | 100001 | N | Bypass |
| HIGHZ | 011111 | N | Bypass |
| RESET: IDCODE Capture: IDCODE<br>0 1 1 1 0 1 | | | |

## 21.8.1 IDCODE

The IDCODE instruction selects the 32-bit DeviceID DR to be logically connected between TDI and TDO during DR shift operations. The capture value of the Device ID DR identifies the manufacturer (Freescale), device type (MPC5200B), and device revision level.

### 21.8.1.1 Device ID Register

**Table 21-3. Device ID Register = 1001 101D Hex**

| Version | Device (MPC5200B – Initial Release) | Manufacturer (Freescale) | |
|---|---|---|---|
| 0001 | 0000 0000 0001 0001 | 0000 0001 110 | 1 |

## 21.8.2 BYPASS

The BYPASS instruction selects the 1-bit Bypass DR to be logically connected between TDI and TDO during DR shift operations. It performs no testing function. The Bypass register provides for a minimum-length serial datapath from TDI to TDO. This allows more rapid test data movement to and from other JTAG scan chain components. The Bypass register capture value is 0. The Bypass register update value has no effect.

## 21.8.3 SAMPLE/PRELOAD

The SAMPLE/PRELOAD instruction selects the Boundary Scan DR to be logically connected between TDI and TDO during DR shift operations. As the name implies, the SAMPLE/PRELOAD instruction has two distinct uses:

**Sample:** To capture and examine the device pins state without disturbing normal system operation. Signals are captured at the TCK rising edge in the Capture-DR state, and examined by shifting out. For captured values to be meaningful, TCK may need to be synchronized to the normal system clock. The update value has no effect.

**Preload:** To shift an initial value into the boundary scan register prior to loading the EXTEST or CLAMP instruction into the Instruction register. Capture value may be examined or ignored. Update value has no effect until EXTEST/CLAMP instruction is loaded. It is then presented at the device pins.

### 21.8.4 EXTEST

The EXTEST instruction selects the Boundary Scan DR to be logically connected between TDI and TDO during DR shift operations. It also forces the Boundary Scan register contents to appear at the pins of the device. The state of all pins is captured at the TCK rising edge in the Capture-DR TAP Controller state. The update value appears on the pins at the TCK falling edge in the Update-DR state. EXTEST does not affect on-chip pull-up or pulldown resistors.

### 21.8.5 CLAMP

The CLAMP instruction forces the contents of the Boundary Scan DR to appear at the boundary of the microprocessor block, just like the EXTEST instruction, but selects the 1-bit Bypass DR to be logically connected between TDI and TDO during DR shift operations. This allows a static data pattern to be driven onto the device pins, while at the same time minimizing the length of shifts to access test data registers on other devices in the JTAG scan chain. CLAMP does not affect on-chip pull-up or pull-down resistors.

### 21.8.6 HIGHZ

The HIGHZ instruction selects the 1-bit Bypass DR to be logically connected between TDI and TDO during DR shift operations, and also forces all output and bidirectional pins of the device into a non-driving state. Input pins, and the input portion of bidirectional pins, are not affected.

## 21.9 e300 COP/BDM Interface

The MPC5200B functional pin interface and internal logic provides access to the embedded e300 processor core through the Freescale standard COP/BDM interface. For information on the connection between COP connector and MPC5200B refer to the MPC5200B Hardware Specifications.

# Appendix A
# Acronyms and Terms

This section contains an alphabetical list of terms, phrases, acronyms, and abbreviations used in this book. Some terms and definitions included are reprinted from *IEEE Std. 754-1985, IEEE Standard for Binary Floating-Point Arithmetic*, copyright ©1985 by the Institute of Electrical and Electronics Engineers, Inc. with permission of the IEEE.

## A

AAL . . . . . ATM Adaptation Layer

ABR . . . . . Available Bit-Rate. *See also* CBR and UBR.

ACR . . . . . Allowed Cell Rate

addr, adr . . . . . address

alm . . . . . alarm

ALE. . . . . Address Latch Enable

ALU . . . . . Arithmetic Logic Unit

APC. . . . . ATM Pace Control unit

ARB . . . . . Microprocessor Arbiter

Architecture . . . . . A detailed specification of requirements for a processor or computer system. It does not specify details of how the processor or computer system must be implemented; instead it provides a template for a family of compatible *implementations*.

Asynchronous exception. . . . *Exceptions* that are caused by events external to the processor's execution. In this document, the term 'asynchronous exception' is used interchangeably with the word *interrupt*.

AT . . . . . Address Types

ATA. . . . . Advanced Technology Attachment—a standard interface used with storage devices such as hard disk drives. ATA drives are also referred to as Integrated Drive Electronics (IDE) drives.

ATAPI . . . . . ATA Packet Interface

ATM . . . . . Asynchronous Transfer Mode

Atomic access . . . . . A bus access that attempts to be part of a read-write operation to the same address uninterrupted by any other access to that address (the term refers to the fact that the transactions are indivisible). The PowerPC architecture implements atomic access through the **lwarx**/**stwcx** instruction pair.

Autobaud. . . . . The process of determining a serial data rate by timing the width of a single bit.

## B

BAT . . . . . Block Address Translation

BB . . . . . Bus Busy

BD . . . . . Buffer Descriptor

BG . . . . . Bus Grant

BI . . . . . Burst Inhibit

Big-Endian (BE) . . . . . A byte-ordering method in memory where the address *n* of a word corresponds to the *Most-Significant Byte*. In an addressed memory word, the bytes are ordered (left to right) 0, 1, 2, 3, with 0 being the Most-Significant Byte. *See also* Little-Endian.

In Big-Endian architectures, the leftmost bytes (those with a lower address) are most significant. For example, consider the number 1025 stored in a 4Byte integer as shown in the table below.

| 00000000 00000000 00000100 00000001 | | |
|---|---|---|
| **Addr** | **Big-Endian** | **Little-Endian** |
| 00 | 00000000 | 00000001 |
| 01 | 00000000 | 00000100 |
| 02 | 00000100 | 00000000 |
| 03 | 00000001 | 00000000 |

BIP . . . . . Bit Interleaved Parity

BIST . . . . . Built-In Self Test

BISYNC . . . . . Binary Synchronous communication

Blockage . . . . . A pipeline stall that occurs when an instruction occupies an execution unit and prevents a subsequent instruction from being dispatched.

Boundedly undefined . . . . . A characteristic of certain operations results not rigidly prescribed by the PowerPC architecture. Boundedly undefined results for a given operation may vary among implementations, and between execution attempts in the same implementation.

Although the architecture does not prescribe the exact behavior for when results are allowed to be boundedly undefined, the results of executing instructions in contexts where results are allowed to be boundedly undefined are constrained to ones that could have been achieved by executing an arbitrary sequence of defined instructions, in valid form, starting in the state the machine was in before attempting to execute the given instruction.

bps . . . . . bits per second

BPU . . . . . Branch Processing Unit

BR . . . . . Bus Request

BRC . . . . . Backward Reporting Cells

Breakpoint. . . . . A programmable event that forces the core to take a breakpoint exception.

BT . . . . . Burst Tolerance

BUID. . . . . Bus Unit ID

Burst . . . . . A bus transfer whose data phase consists of a sequence of transfers. For example, on a 64-bit bus, a four-beat burst can transfer four, 64-bit double words.

Bus parking. . . . . A feature that optimizes bus usage by letting a device retain bus mastership without having to rearbitrate.

## C

Cache . . . . . High-speed memory component containing recently accessed data and/or instructions (subset of main memory).

Cache coherency. . . . . An attribute in which an accurate and common view of memory is provided to all devices that share a memory system. Caches are coherent if a processor performing a read from its cache is supplied with data corresponding to the most recent value written to memory or to another processor's cache.

Cache flush . . . . . An operation that removes from a cache any data from a specified address range. This operation ensures any modified data within the specified address range is written back to main memory. This operation is generated typically by a Data Cache Block Flush (**dcbf**) instruction.

Caching-inhibited . . . . . A memory update policy in which the *cache* is bypassed and the load or store is done to or from main memory.

CAM . . . . . Content Addressable Memory

CAN . . . . . Controller Area Network

Cast-outs . . . . . *Cache blocks* that must be written to memory when a cache miss causes a cache block to be replaced.

CBR . . . . . Constant Bit-Rate. *See also* UBR and ABR.

CD. . . . . Carrier Detect

CDM . . . . . Clock Distribution Module

CDV . . . . . Cell Delay Variation

CEPT. . . . . Conference des administrations Europeanes des Postes et Telecommunications (European Conference of Postal and Telecommunications Administrations).

CES . . . . . Circuit Emulation Service

cfg . . . . . configuration

Changed bit. . . . . One of two *page history bits* found in each *page table entry* (PTE). The processor sets the changed bit if any store is performed into the *page*. *See also* Page access history bits and Referenced bit.

C/I. . . . . Condition/Indication (channel used in GCI protocol)
Clear . . . . . To cause a bit or bit field to register a value of 0. The opposite of *set*.
CLP . . . . . Cell Loss Priority
cmd . . . . . command
cnt . . . . . count
CODEC. . . . . COder/DECoder, or COmpression/DECommpression
Context synchronization . . . . An operation that ensures:

- All instructions in execution complete past the point where they can produce an *exception*
- All instructions in execution complete in the context in which they began execution
- All subsequent instructions are *fetched* and executed in the new context.

. . . . . Context synchronization may result from executing specific instructions (such as **isync** or **rfi**) or when certain events occur (such as an exception).
COP. . . . . Common On-chip Processor
Copy-back. . . . . An operation in which modified data in a *cache block* is copied back to memory.
CP . . . . . Communications Processor
CPI . . . . . Common Part Indicators
CPM . . . . . Communications Processor Module
CPS . . . . . Cells Per Slot
CQ. . . . . Completion Queue
CR. . . . . Condition Register
CRC . . . . . Cyclic Redundancy Check—Error detecting codes that generate a parity check.
Critical-data first. . . . . An aspect of *burst* access that lets requested data (typically a word or double word) in a *cache block* be transferred first.
CS . . . . . Chip Select, or Convergence Sublayer
CSC. . . . . Chip Select Controller—LocalPlus Controller
CSMA. . . . . Carrier Sense Multiple Access
CT . . . . . Connection Table
CTL, ctl. . . . . Control
CTR. . . . . Count Register
CUMB. . . . . Check Unused Mask Bits

## D

DABR . . . . . Data Address Breakpoint Register
DAR . . . . . Data Address Register

DDR . . . . . Dual-Data Rate

DEC . . . . . Decrementer (register)

Denormalized number. . . . . A non-zero floating-point number whose *exponent* has:

- A reserved value, usually the format's minimum, and
- whose explicit or implicit leading significant bit is 0.

Direct-mapped cache . . . . . A cache in which each main memory address can appear in only one location within the cache, operates more quickly when the memory request is a cache hit.

Direct-store . . . . . Interface available only on microprocessors that use the PowerPC architecture; supports direct-store devices from the POWER architecture. When the T-bit of a *segment descriptor* is set, the descriptor defines the region of memory to be used as a direct-store segment.

This facility is being phased out of the architecture and is not likely be supported in future devices. Therefore, software should not depend on it and new software should not use it.

DMA . . . . . Direct Memory Access

DPLL . . . . . Digital Phase-Locked Loop

DPR. . . . . Dual-Port RAM

DR. . . . . Data Register

DRAM . . . . . Dynamic Random Access Memory

DSI . . . . . Data Storage Interrupt

DSISR . . . . . DSI Source Register—a register used for determining the source of a DSI exception.

DTLB . . . . . Data Translation Lookaside Buffer

DTV . . . . . Digital TV

DWPCI . . . . . designware PCI—synopsys designware component

## E

EA . . . . . Effective Address—The 32- or 64-bit address specified for a load, store, or instruction fetch. This address is then submitted to the MMU for translation to either a *physical memory* address or an I/O address.

ED . . . . . Endpoint Descriptor

EEST. . . . . Enhanced Ethernet Serial Transceiver

en. . . . . enable

EPROM. . . . . Erasable Programmable Read-Only Memory

err . . . . . error

ESAR . . . . . Enhanced Segmentation And Reassembly

ETH. . . . . Ethernet

Exception . . . . . A condition encountered by the processor that requires special, supervisor-level processing.

Exception handler . . . . . A software routine that executes when an exception is taken. Normally, the exception handler corrects the condition that caused the exception, or performs some other meaningful task, which may include aborting the program that caused the exception. The address for each exception handler is identified by an exception vector offset defined by the architecture and a prefix selected by the MSR.

Extended opcode. . . . . A secondary opcode field generally located in instruction bits 21–30, that further defines the instruction type. All instructions are one word in length. The most significant 6 bits of the instruction are the *primary opcode*, identifying the type of instruction. *See also* Primary opcode.

Execution synchronization. . . A mechanism by which all instructions in execution are architecturally complete before beginning execution (appearing to begin execution) of the next instruction. Similar to context synchronization, but doesn't force contents of the instruction buffers to be deleted and refetched.

Exponent . . . . . In a floating-point number binary representation, the exponent is the component that signifies the integer power to which the value two is raised in determining the value of the represented number. *See also* Biased exponent.

EXTAL . . . . . External Crystal. *See also* XTAL.

## F

FBP . . . . . Free Buffer Pool

FEC . . . . . Fast Ethernet Controller

Fetch . . . . . Retrieving instructions from either the cache or main memory and placing them into the instruction queue.

FIFO . . . . . First-In-First-Out (buffer)

FIR . . . . . Fast Infrared. *See also* MIR and SIR.

FMC . . . . . Forward Monitor Cells

FPR . . . . . Floating Point Register

FPSCR . . . . . Floating Point Status and Control Register

FPU . . . . . Floating Point Unit

FRM . . . . . Forward Resource Management

flg . . . . . flag

FLT . . . . . First-Level Table. *See also* SLT.

Fully-associative . . . . . Addressing scheme where every cache location (every byte) can have any possible address.

## G

Gb, Gbit . . . . . Gigabit (written with lowercase b; 1024 megabits)

GB, GByte . . . . . Giga-Byte (written with upper case B; 1024 MegaBytes)

GCI . . . . . General Circuit Interface
GCRA . . . . . Generic Cell Rate Algorithm (leaky bucket)
GFC. . . . . Generic Flow Control
GPCM . . . . . General-Purpose Chip-select Machine
GPIO . . . . . General Purpose Input Output (standard)
GPR. . . . . General-Purpose Register—Any of the 32 registers in the general-purpose register file. These registers provide the source operands and destination results for all integer data manipulation instructions. Integer load instructions move data from memory to GPRs and store instructions move data from GPRs to memory.
GPTMR. . . . . General Purpose Timer
GUI . . . . . Graphical User Interface

## H

Harvard architecture . . . . . An architectural model featuring separate caches for instruction and data.
HC, Hc . . . . . Host Controller
HCD . . . . . Host Controller Driver
HDLC . . . . . High-level Data Link Control—a transmission protocol used at the data link layer (layer 2) of the OSI seven layer model for data communications. The HDLC protocol embeds information in a data frame that allows devices to control data flow and correct errors.
. . . . . HDLC is an ISO standard developed from the Synchronous Data Link Control (SDLC) standard proposed by IBM.
HEC . . . . . Header Error Control

## I

ICTL . . . . . Interrupt Controller
IEEE . . . . . Institute of Electrical and Electronics Engineers
IEEE 754 . . . . . A standard, written by the Institute of Electrical and Electronics Engineers, which defines operations and representations of binary floating-point arithmetic.
$I^2C$. . . . . Inter-Integrated Circuit
IC . . . . . Input Capture. *Also see* OC and PWM.
IDE . . . . . Integrated Drive Electronics—Interface for connecting additional hard drives to a computer.
IDL . . . . . Inter-chip Digital Link
IDMA . . . . . Internal Direct Memory Access

Illegal instructions. . . . . A class of instructions not implemented for a particular microprocessor. These include instructions not defined by the PowerPC architecture. In addition:

- For 32-bit implementations, instructions defined for 64-bit implementations only are considered illegal instructions.
- For 64-bit implementations, instructions defined for 32-bit implementations only are considered illegal instructions.

Implementation . . . . . A particular processor that conforms to the PowerPC architecture, but may differ from other architecture-compliant implementations; for example, in design, feature set, and implementation of *optional* features. The PowerPC architecture has many different implementations.

Implementation-dependent . . An aspect of a feature in a processor's design that is defined by a processor's design specifications, rather than by the PowerPC architecture.

Implementation-specific . . . . An aspect of a feature in a processor's design that is not required by the PowerPC architecture, but for which the PowerPC architecture may provide concessions to ensure processors implementing the feature do so consistently.

Imprecise exception . . . . . A type of *synchronous exception* that is allowed not to adhere to the precise exception model. *See also* Precise exception. The PowerPC architecture lets only floating-point exceptions be handled imprecisely.

individual serial controllers . SCC, SMC, SPI, $I^2C$, and USB—these individual serial controllers request service from the CPM.

Internal bus . . . . . bus that connects the core and System Interface Unit (SIU).

Instruction latency. . . . . The total number of clock cycles necessary to execute an instruction and make ready the results of that instruction.

int . . . . . interrupt

Interrupt . . . . . An *asynchronous exception*—on processors that use the PowerPC architecture, interrupts are a special case of exceptions. *See also* asynchronous exception.

IP. . . . . Intellectual Property—a unique number that identifies a particular computer in a network of computers. The IP part of TCP/IP; a protocol used to route a data packet from its source to its destination.

IPBI, IP bus. . . . . IP Bus Interface—the Intellectual Property Bus Interface

IR . . . . . Infrared

IR . . . . . Instruction Register

IrDA, IRDA . . . . . Infrared Data Association

IRQ . . . . . Interrupt Request

ISI . . . . . Instruction Storage Interrupt

ITLB . . . . . Instruction Translation Lookaside Buffer

IU . . . . . Integer Unit

## J

JAVA™ . . . . . From Sun Microsystems, Inc.—a robust and versatile programming language that enables developers to:

- Write software on one platform and run it on another.
- Create programs to run within a web browser.
- Develop server-side applications for online forums, stores, polls, processing HTML forms, and more.
- Write applications for cell phones, two-way pagers, and other consumer devices.

JTAG . . . . . Joint Test Action Group

## K

Kbps . . . . . thousand (K) bits per second

Kb, Kbit . . . . . Kilobit (written with lowercase b; 1024 Bytes)

KB, KByte . . . . . KiloByte (written with uppercase B; 1024 bits)

## L

LAN . . . . . Local Area Network—A computer network that spans a relatively small area. Most LANs are confined to a single building or group of buildings. However, one LAN can be connected to other LANs over any distance via telephone lines and radio waves. A system of LANs connected in this way is called a Wide-Area Network (WAN).

LANs are capable of transmitting data at fast rates, much faster than data can be transmitted over a telephone line. However, distances are limited. There is also a limit on the number of computers that can be attached to a single LAN.

Latency . . . . . The time an operation requires. For example:

- Execution latency is the number of processor clocks an instruction takes to execute.
- Memory latency is the number of bus clocks needed to perform a memory operation.

ld . . . . . load

LIFO . . . . . Last-In-First-Out (buffer)

Little-Endian (LE) . . . . . A byte-ordering method in memory where the address *n* of a word corresponds to the *Least-Significant Byte*. In an addressed memory word, the bytes are ordered (left to right) 3, 2, 1, 0, with 3 being the *Most-Significant Byte*. *See also* Big-Endian.

In Little-Endian architectures, the rightmost bytes (those with a higher address) are most significant. For example, consider the number 1025 stored in a 4Byte integer as shown in the table below.

| 00000000 00000000 00000100 00000001 | | |
|---|---|---|
| **Addr** | **Big-Endian** | **Little-Endian** |
| 00 | 00000000 | 00000001 |
| 01 | 00000000 | 00000100 |
| 02 | 00000100 | 00000000 |
| 03 | 00000001 | 00000000 |

LP . . . . . LocalPlus

LR . . . . . Link Register

LRU . . . . . Least Recently Used

lsb . . . . . least significant bit—the *bit* of least value in an address, register, data element, or instruction encoding.

LSB . . . . . Least Significant Byte—the *Byte* of least value in an address, register, data element, or instruction encoding.

LSU . . . . . Load/Store Unit

## M

MA . . . . . Memory Address

MAC . . . . . Media Access Control

MAC/PHY . . . . . Multiply-and-ACcumulate/Physical Layer Device

Master . . . . . Name given to a bus device granted control, or mastership, of the bus.

MBAR. . . . . Module Base Address Register

Mb, Mbit . . . . . Megabit (written with lowercase b; 1024 Kilobits)

MB, MByte . . . . . MegaByte (written with uppercase B; 1024 KiloBytes)

Mbps . . . . . Million bits per second

MBS . . . . . Maximum Burst Size

MC . . . . . Memory Controller

MEMCTL . . . . . SDRAM Controller

Memory access ordering . . . . The specific order in which the processor performs load and store memory access and the order in which those accesses complete.

Memory Controller . . . . . A unit whose primary function is to control the external bus memories and I/O devices.

Memory coherency . . . . . An aspect of caching in which it is ensured an accurate view of memory is provided to all devices sharing system memory.

Memory consistency . . . . . Refers to agreement of levels of memory with respect to a single processor and system memory. For example, on-chip cache, secondary cache, and system memory.

Microarchitecture . . . . . Hardware details of a microprocessor's design. Such details are not defined by the PowerPC architecture.

MII . . . . . Media-Independent Interface

mips. . . . . million instructions per second

MIR. . . . . Medium Infrared. *See also* FIR and SIR.

MMAP . . . . . Memory Map

MMU . . . . . Memory Management Unit—a functional unit capable of translating an *effective* (logical) *address* to a physical address, providing protection mechanisms, and defining caching methods.

Mnemonic . . . . . The abbreviated name of an instruction used for coding.

mod . . . . . mode

Modified state . . . . . When a cache block is in the modified state, it has been modified by the processor since it was copied from memory. *See also* MESI.

MPC603e . . . . . A microprocessor—a low-power implementation of the PowerPC Reduced Instruction Set Computer (RISC) architecture. The MPC603e microprocessor offers workstation-level performance packed into a low-power, low-cost design ideal for desktop computers, notebooks and battery-powered systems, as well as printer and imaging equipment, telecommunications systems, networking and communications infrastructure, industrial controls, and home entertainment and educational devices.

Munging . . . . . A modification performed on an *effective address* that allows it to appear to the processor that individual aligned scalars are stored as Little-Endian values, when in fact it is stored in Big-Endian order, but at different byte addresses within double words.

**NOTE**

Munging affects only the effective address and not the byte order. The PowerPC architecture does not use this term.

MS. . . . . Motorola Scalable

msb . . . . . most significant bit—highest-order *bit* in an address, register, data element, or instruction encoding.

MSB . . . . . Most Significant Byt**e**—highest-order *Byte* in an address, register, data element, or instruction encoding.

MSCAN . . . . . Motorola Scalable CAN (Controller Area Network)

MSR . . . . . Main Shift Register, or Machine State Register

## N

NaN . . . . . Not a Number

NCITS . . . . . Number of Cells In Time Slot

NIC . . . . . Network Interface Card

NMI . . . . . Non-Maskable Interrupt

NMSI . . . . . Non-Multiplexed Serial Interface

No-op . . . . . No-operation—a single-cycle operation that does not affect registers or generate bus activity

NRT . . . . . Non-Real Time

## O

OC . . . . . Output Compare

OE . . . . . Output Enable signal

OEA . . . . . Operating Environment Architecture—the level of PowerPC architecture that describes memory management model, supervisor-level registers, synchronization requirements, and the exception model. It also defines the time-base feature from a supervisor-level perspective.

OHCI . . . . . Open Host Controller Interface—an Open Host standard.

Option, Optional . . . . . A feature, such as an instruction, register, or exception, defined by the PowerPC architecture, but not required to be implemented.

OSI . . . . . Open Systems Interconnection

Out-of-order . . . . . An aspect of an operation that lets it be performed ahead of one that may have preceded it in the sequential model. For example, speculative operations. An operation is said to be performed out-of-order if, at the time it is performed, it is not known to be required by the sequential execution model. *See also* In-order.

Out-of-order execution . . . . . A technique that lets instructions be issued and completed in an order that differs from their sequence in the instruction stream.

Overflow . . . . . An error condition that occurs during arithmetic operations when the result cannot be stored accurately in the destination register(s). For example, if two 32-bit numbers are multiplied, the result may not be representable in 32 bits.

## P

Pace control . . . . . Controls the data flow rate between a master and slave.

Page . . . . . A region in memory. The OEA defines a page as a 4KByte area of memory, aligned on a 4KByte boundary.

Page fault . . . . . A page fault is a condition that occurs when the processor attempts to access a memory location that does not reside within a *page* not currently resident in *physical memory.* On microprocessors that use the PowerPC architecture,

| | |
|---|---|
| | a page fault exception condition occurs when a matching, valid *page table entry* (PTE[V]=1) cannot be located. |
| PCI | Peripheral Component Interconnect |
| PCMCIA | Personal Computer Memory Card International Association |
| PCR | Peak Cell Rate |
| PDU | Protocol Data Unit |
| PHY | Physical Layer Device |
| Physical memory | The actual memory that can be accessed through the system memory bus. |
| PIP | Parallel Interface Port |
| Pipelining | A technique that breaks operations (such as instruction processing or bus transactions) into smaller distinct stages or tenures (respectively) so that a subsequent operation can begin before the previous one has completed. |
| PIT | Periodic Interrupt Timer |
| PLL | Phase-Locked Loop |
| PM | Performance Monitors |
| PMD | Physical Media-Dependent |
| POTS | Plain Old Telephone Service—refers to the standard telephone service that most homes use. The main distinctions between POTS and non-POTS services are speed and bandwidth. POTS is generally restricted to about 52Kbps. The POTS network is also called the public switched telephone network (PSTN). |
| PPC | Port Power Control |
| PPM | Pulse-Position Modulation |
| Precise exceptions | A category of exception for which the pipeline can be stopped so that instructions preceding the faulting instruction can complete. Subsequent instructions can then be flushed and redispatched after exception handling has completed. *See also* Imprecise exceptions. |
| pri | priority |
| Primary opcode | The most-significant 6 bits (bits 0–5) of the instruction encoding that identifies the type of instruction. S*ee also* Secondary opcode. |
| Protection boundary | A boundary between *protection domains*. |
| Protection domain | a segment, virtual page, BAT area, or range of unmapped effective addresses. It is defined only when the appropriate relocate bit in the MSR (IR or DR) is 1. |
| PSC | Programmable Serial Controller |
| PTE | Page Table Entry |
| PTI | Payload Type Identifier |
| PTP | Port-To-Port switching |
| PTR | Program Trace |

PVR. . . . . Processor Version Register
PWM. . . . . Pulse Width Modulator

## Q

QNX . . . . . From QNX Software Systems—a hybrid realtime platform that represents a cross between a realtime operating system and a platform OS. The first integrated, self-hosted, graphical platform for embedded developers.
Quad word. . . . . A group of 16 contiguous locations starting at an address divisible by 16.

## R

rA . . . . . The rA instruction field specifies a GPR used as a source or destination.
rB . . . . . The rB instruction field specifies a GPR used as a source.
rD . . . . . The rD instruction field specifies a GPR used as a destination.
rS. . . . . The rS instruction field specifies a GPR used as a source.
RCT. . . . . Receive Connection Table
RD. . . . . Read
Real address mode . . . . . An MMU mode when no address translation is done and the *effective address* specified is the same as the physical address. The processor's MMU is operating in real address mode if its ability to perform address translation has been disabled through the MSR registers IR and/or DR bits.
Record bit . . . . . Bit 31 (or the Rc bit) in the instruction encoding. When set, it updates the condition register (CR) to reflect the result of the operation.
Registers . . . . . See Chapter 3, "Memory Map".
Register indirect addressing. . A form of addressing that specifies one GPR that contains the address for the load or store.
Register indirect with . . . . . A form of addressing that specifies an immediate value to
immediate index addressing. . be added to the contents of a specified GPR to form the target address for the load or store.
Register indirect with . . . . . A form of addressing that specifies that the contents of two
index addressing . . . . . GPRs be added together to yield the target address for the load or store.
Reservation . . . . . The processor establishes a reservation on a *cache block* of memory space when it executes an **lwarx** instruction to read a memory semaphore into a GPR.
Reserved field . . . . . In a register, a reserved field is one not assigned a function. A reserved field may be a single bit. The handling of reserved bits is *implementation-dependent*. Software is allowed to write any value to such a bit. A subsequent reading of the bit returns 0 if the value last written to the bit was 0; otherwise, it returns an undefined value (0 or 1).

RISC . . . . . Reduced Instruction Set Computing—an *architecture* characterized by fixed-length instructions with non-overlapping functionality and a separate set of load and store instructions that perform memory access.

RM . . . . . Resource Management

rst . . . . . reset

RSV. . . . . Reservation

RT . . . . . Real Time

RTC. . . . . Real-Time Clock

RTOS. . . . . Real-Time Operating System

R/W . . . . . Read/Write

rwc . . . . . read-write-clear

RWITM. . . . . Read With Intent To Modify

Rx, RX . . . . . Receive

## S

SAR. . . . . Segment And Reassemble

Scalability . . . . . The capability of an architecture to generate *implementations* specific for a wide range of purposes, and in particular implementations of significantly greater performance and/or functionality than at present, while maintaining compatibility with current implementations.

Scan chain . . . . . The peripheral buffers of a device, linked in JTAG test mode, that are addressed in a shift-register fashion.

SCC. . . . . Serial Communication Controller

SCP . . . . . Serial Control Port

SCR. . . . . Sustained Cell Rate

SDLC . . . . . Synchronous Data Link Control

SDRAM . . . . . Synchronous Dynamic RAM—a faster version of DRAM. SDRAM is generally synchronized with the clock speed for which the microprocessor is optimized. This tends to increase the number of instructions the processor can perform in a given time. The speed of SDRAM is rated in MHz rather than in nanoseconds (ns). This makes it easier to compare the bus speed and the RAM chip speed. You can convert the RAM clock speed to nanoseconds by dividing the chip speed into 1 billion ns (which is one second). For example, an 83MHz RAM would be equivalent to 12ns.

sel . . . . . select

Set (*v*) . . . . . To write a non-zero value to a bit or bit field; the opposite of *clear*. The term **set** may also be used to generally describe the updating of a bit or bit field.

Set (*n*) . . . . . A subdivision of a *cache*. Cacheable data can be stored in a given location in any one of the sets, typically corresponding to its lower-order address bits. Because several memory locations can map to the same location,

| | |
|---|---|
| | cached data is typically placed in the set whose *cache block* corresponding to that address was least recently used (LRU). *See also* Set-associative. |
| Set-associative | Aspect of cache organization in which cache space is divided into sections, called *sets*. The cache controller associates a particular main memory address with the contents of a particular set, or region, within the cache. |
| Signals | See Table 2-1. Signals by Ball/Pin and Table 2-2. Signals by Signal Name. |
| Significand | The component of a binary floating-point number that consists of an explicit or implicit leading bit to the left of its implied binary point and a fraction field to the right. |
| SI | Serial Interface |
| SIM | System Integration Module |
| SIMM | Signed IMMediate Value, or Single In-line Memory Module |
| SIP | Serial Infrared Interaction Pulse |
| SIR | Slow Infrared. *See also* FIR and MIR. |
| SIU | Systems Interface Unit |
| Slave | A device that responds to the master's address. A slave receives data on a write cycle and gives data to the master on a read cycle. |
| SLT | Second-Level Tables. *See also* FLT. |
| SLTMR | Slice Timer |
| SMC | Serial Management Controllers |
| SNA | Systems Network Architecture |
| SPI | Serial Peripheral Interface—the SPI channel supports the out-of-band control channel to external physical chips. The SPI module allows full-duplex, synchronous, serial communication between the MPC5200B and peripheral devices. It supports master and slave mode, double-buffered operation and can operate in a polling or interrupt driven environment. |
| SPR | Special-Purpose Register |
| SR | Segment Register |
| SRAM | Static Random Access Memory—a type of memory that is faster and more reliable than the more common DRAM (Dynamic RAM). The term **static** is derived from the fact that it does not need to be refreshed like DRAM. |
| SRR0 | machine Status save/Restore Register 0 |
| SRR1 | machine Status save/Restore Register 1 |
| SRTS | Synchronous Residual Time Stamp |
| SRU | System Register Unit |
| sta | status |
| Static branch prediction | Mechanism by which software (for example, compilers) can give a hint to the machine hardware about the direction a branch is likely to take. |
| STB | Set-Top Box |

Sticky bit . . . . . A bit that when *set* must be cleared explicitly.
stp . . . . . stop
str . . . . . start
STS . . . . . Special Transfer Start
Superscalar machine . . . . . A machine that can issue multiple instructions concurrently from a conventional linear instruction stream.
Supervisor mode . . . . . The privileged operation state of a processor. In supervisor mode, software (typically the operating system) can access all control registers and the supervisor memory space, among other privileged operations.
SWT . . . . . Software Watchdog Timer
Synchronization . . . . . A process to ensure operations occur *in order. See also* Context synchronization and Execution synchronization.
Synchronous exception . . . . . An *exception* generated by the execution of a particular instruction or instruction sequence. There are two types of synchronous exceptions, *precise* and *imprecise*.
System memory . . . . . The physical memory available to a processor.

## T

TA . . . . . Transfer Acknowledge
TAP . . . . . Test Access Port
TB . . . . . Time Base (register)
TC . . . . . Transmission Convergence
TCT . . . . . Transmit Connection Table
TDM . . . . . Time-Division Multiplex—a single serial channel used by several channels taking turns.
TE . . . . . Terminal Endpoint
TEA . . . . . Transfer Error Acknowledge
Throughput . . . . . A measure of the number of instructions processed per clock cycle.
TLB . . . . . Translation Lookaside Buffer—A cache that holds recently-used *page table entries*.
TLE . . . . . True Little-Endian
TMR, tmr . . . . . Timer
TO, to . . . . . Timeout
TS . . . . . Transfer Start
TSA . . . . . Time-Slot Assigner
tst . . . . . test
TSIZ . . . . . Transfer Size
Tx, TX . . . . . Transmit

## U

UART . . . . . Universal Asynchronous Receiver-Transmitter—a component that handles asynchronous serial communication.

UARTe . . . . . UART enhanced (simple UART with carrier detect input)

UBR . . . . . Unspecified Bit-Rate. *See also* CBR and ABR.

UBR+ . . . . . Unspecified Bit-Rat**e with minimum cell rate guarantee**

UIMM . . . . . Unsigned IMMediate value

UISA . . . . . User Instruction Set Architecture**—**the level of the architecture to which user-level software should conform. The UISA defines the base user-level instruction set, user-level registers, data types, floating-point memory conventions and exception model as seen by user programs, and the memory and programming models.

UPM . . . . . User-Programmable Machine

USART . . . . . Universal Synchronous/Asynchronous Rx/Tx

USB. . . . . Universal Serial Bus—a new external bus standard that supports data transfer rates of 12 Mbps.

User mode . . . . . The unprivileged operating state of a processor used typically by application software. In user mode, software can only access certain control registers and can access only user memory space. No privileged operations can be performed. Also referred to as problem state.

UTOPIA . . . . . Universal Test and Operations Physical Interface for ATM

## V

VA . . . . . Virtual Address—an intermediate address used in translation of an *effective address* to a physical address.

VBR . . . . . Variable Bit-Rate

VC. . . . . Virtual Channel, Circuit, Call, or Connection

VCC . . . . . Virtual Channel Connection

VCI . . . . . Virtual Circuit Identifier

VCO . . . . . Voltage-Controlled Oscillator

VEA . . . . . Virtual Environment Architecture**—**the level of the *architecture* that describes the memory model for an environment in which multiple devices can access memory. VEA can:

- Define aspects of the cache model
- Define cache control instructions
- Define the time-base facility from a user perspective.

ver . . . . . version

VM . . . . . Virtual Memory—the address space created using the memory management facilities of the processor. Program access to virtual memory is possible only when it coincides with *physical memory.*

VP . . . . . Virtual Path
VPC. . . . . Virtual Path Connection
VPI . . . . . Virtual Path Identifier

## W

WAN . . . . . Wide Area Network—A computer network that spans a relatively large geographical area. Typically, a WAN consists of two or more local-area networks (LANs).
Watchpoint . . . . . A reported event, but does not change machine timing.
WE . . . . . Write Enable signals
WKIO . . . . . GPIO WakeUp
Word . . . . . A 32-bit data element.

**NOTE**

Other processors may have a different word size.

WR . . . . . Write
Write-back. . . . . A cache memory update policy in which processor write cycles are directly written only to the cache. External memory is updated only indirectly. For example, when a modified cache block is *cast out* to make room for newer data.
Write-through . . . . . A cache memory update policy in which all processor write cycles are written to both cache and memory.

## X

XCPCI. . . . . PCI_CFG (PCI configuration)
XER . . . . . Register used primarily for indicating conditions such as carries and overflows for integer operations.
XFC. . . . . External Filter Capacitor
XTAL . . . . . Crystal. *See also* EXTAL.
VxWorks . . . . . From Wind River Systems, is a networked real-time operating system designed to be used in a distributed environment.

# Appendix B
# Revision History

This appendix describes corrections to the *MPC5200B User Manual*. For convenience, the corrections are grouped by revision.

## B.1 Changes Between Revisions 1.3 and 2

**Table B-1. Changes Between Revisions 1.3 and 2**

| Chapter | Description |
|---|---|
| PSC | Added text to section “ SPI Mode,” to clarify the behavior of the PSC SPI mode. |

## B.2 Changes Between Revisions 2 and 3

**Table B-2. Changes Between Revisions 2 and 3**

| Chapter | Description |
|---|---|
| Signals | Updated Table 2-6 “PCI Dedicated Signals”, Description column, LFLASH and MOST graphics rows: changed A17 to A18, changed A1 to A2. |
| SIU | GPS Port Configuration Register, PCS2 bits: changed "see Note 3" to "see Note 1" for 0b001 combination.<br>GPW WakeUp GPIO Status Register, lstat[0:7]: changed reset value from 0xFF to 0x00.<br>Duplicate register name "GPS GPIO Simple Interrupt Enable Register". Changed first instance to be "GPS GPIO Simple Interrupt Pin Enable Register" (bit field for this register is SIGPIOE)<br>Fixed typo: “GETH_15” to “ETH_15” |
| PSC | Updated UNEX_RX_SLOT bit field description (in the SR register).<br>Fixed bit width for AC97Slots[RX_Slots] (replaced "22:3`" with "22:31") |
| MSCAN | Changed CANCTL1[WUPM] bit to Reserved (bit 5 in the register).<br>Removed text: "The sensitivity to existing bus action can be modified by applying a low-pass filter function to the RXCAN input line while in Sleep Mode (see control bit WUPM in Section 19.5.2.2, "MSCAN Control Register 1 (CANCTL1)"). This feature can be used to protect the MSCAN from wake-up due to short glitches on the CAN bus lines. Such glitches can result, for example, from electromagnetic interference within noisy environments." |